FOREST PRODUCTS JOURNAL

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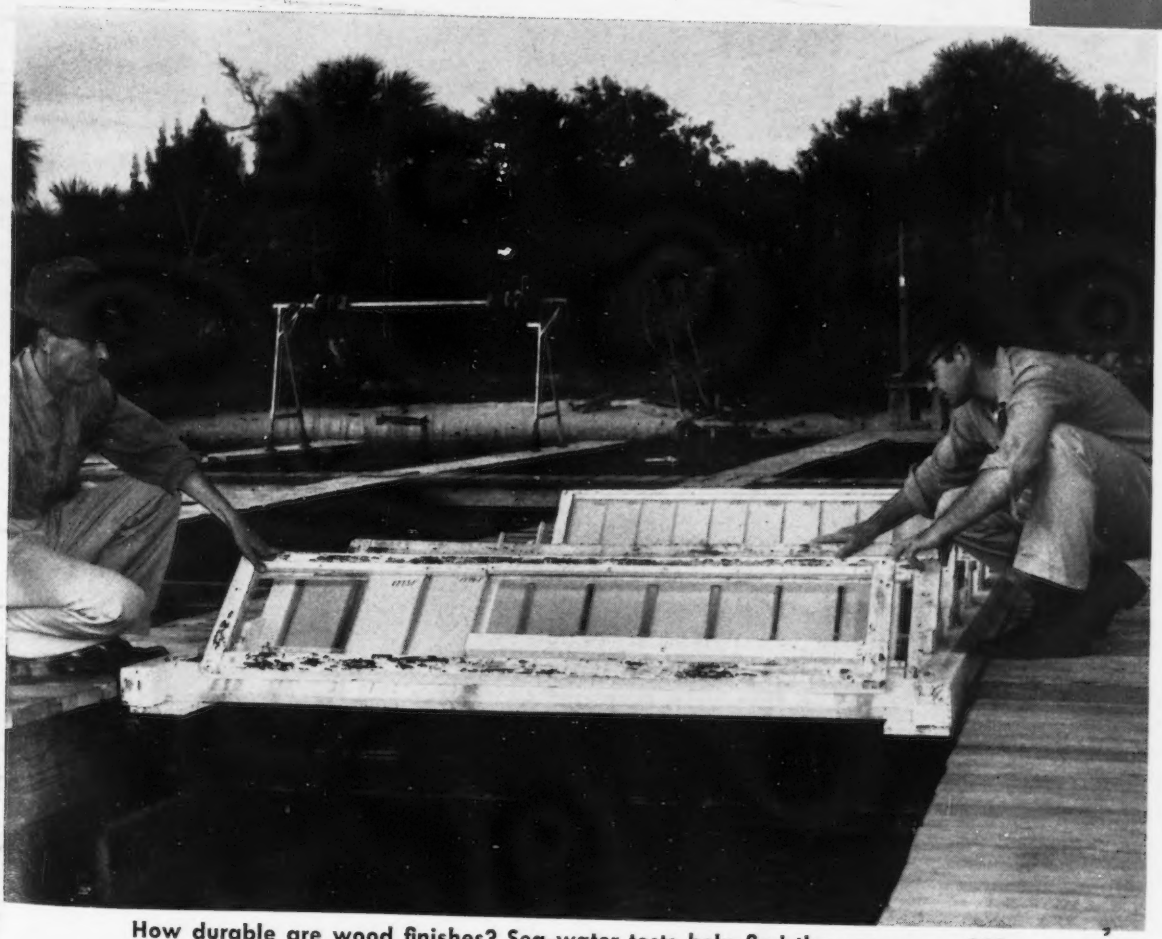

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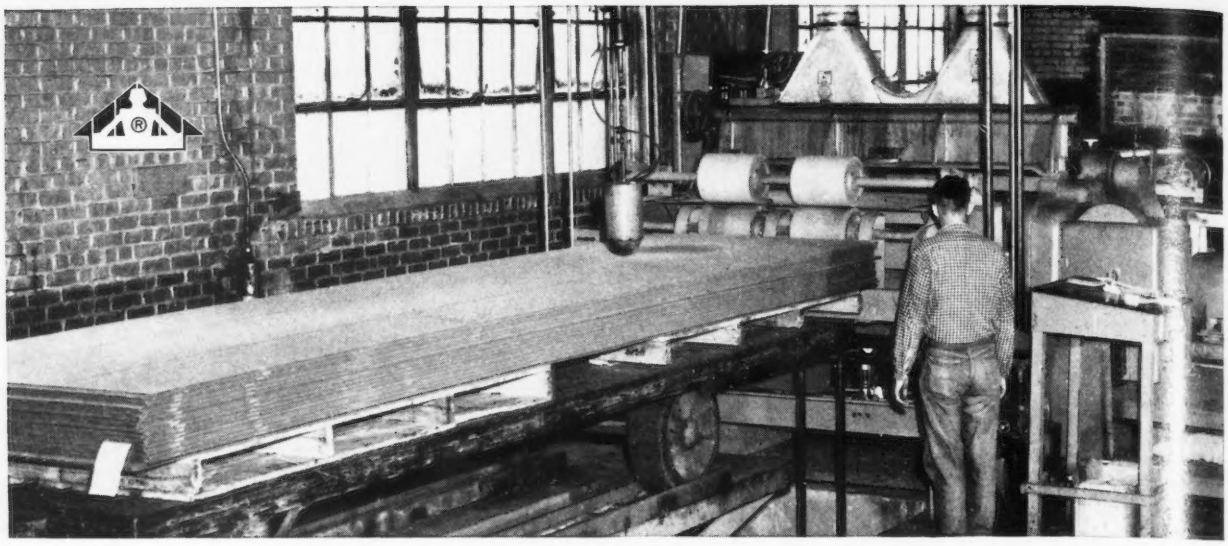

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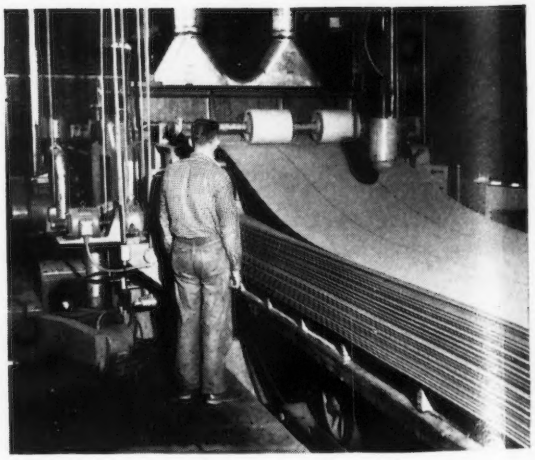

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Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

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the Publications Committee
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FPRS News-Digest

Executive Board Clarifies SWST-FPRS Relations

At the recent Executive Board Meeting of FPRS in Montreal on June 9, the Board moved to terminate the existing working agreement between SWST and FPRS, but to continue the relationship as two separate and distinct organizations with bonds of common interests.

It was emphasized that it was the individual and collective desire of all board members to encourage, help, and lend their support to the development of a strong professional society of wood technologists.

The Board invited SWST to continue to hold its annual business meeting when FPRS convenes annually. It was further suggested that the sessions of the newly created Anatomy and Fundamental Properties subject matter division would be, insofar as possible, scheduled on the first or last day of FPRS's series of technical sessions, thus permitting SWST to hold its meeting on the day prior to the opening or immediately following FPRS meetings.

The feeling of the Executive Board was expressed in a recent report of the Board's action to SWST President, Dr. S. B. Preston, University of Michigan, by Dr. E. S. Harrar, immediate Past President: " . . . this is an ideal arrangement inasmuch as many of us are members of both societies, and wish to see each one take its rightful place in the sun. I am sure by working independently as societies but together in a mutually sympathetic and harmonious atmosphere as individuals, that both organizations will continue to grow in numbers and stature in the productive years that lie ahead."

Mid-South Section To Meet in Memphis

The Mid-South Section of the Forest Products Research Society will hold its annual meeting from September 28th to October 1st at the Parkview Hotel in Memphis, Tennessee.

"Research for Wood's Survival in the Market Place" will be the topic discussed at the technical sessions with James R. Welsh, founder and Ex-President of Welsh Plywood Corp., Memphis; Fritz Deane, President of Nelsonite Chemical Products Company, Grand Rapids, Michigan; Art Cleveland, Manager of Dover Elevator Corporation, West Memphis, Arkansas; W. D. Page of Plywood Fabricators Service, Chicago; Carlton Smith, President of Fan Air Drying Systems, Memphis; and W. J. Eason, Vice-President of Nickey Brothers, Inc., Memphis, and Past President of the Forest Products Research Society as speakers. Plant tours will be made on September 30th of Nickey Brothers, Inc., Forest Products Chemical Company, and United Wood Corporation.

For entertainment a "Lufthansa Night" party is planned for the 29th with food and service provided and supervised by the Lufthansa personnel who were present on the F.P.R.S. chartered flight in May from Paris. There will be a dance the evening of the 30th and tickets will be available for the Tennessee–Mississippi State football game on October 1st.

Important FPRS Dates

August 29–September 10: Fifth World Forestry Congress, Seattle, Wash.
September 28–October 1: Midsouth Section Meeting, Memphis, Tenn.
October 14–15: Northeast Section Meeting, New Haven, Conn.
October 16–17: Executive Board Meeting, Madison, Wis.
October 16–22: National Forest Products Week, Nation-Wide.
October 20–21. Midwest Section Meeting, Madison, Wis.
October 21–22: Upper Mississippi Valley Section Meeting, St. Paul, Minn.
October __: Northern California Section Meeting, Stockton, Calif.

K. E. Huddleston Appointed FPRS Executive Secretary

FPRS President R. H. Berry has announced the appointment of Kenneth E. Huddleston as new Executive Secretary of FPRS. His appointment was approved by the Executive Board following the acceptance of the resignation of Frank J. Rovsek who is leaving FPRS to take an executive position with the American Hardboard Association in Chicago.

Huddleston

Rovsek

Mr. Huddleston joined FPRS July 15, leaving his position as Communications Director of Crane Co., Chicago, Illinois, the leading manufacturer of industrial valves and piping, plumbing, heating, and air conditioning equipment, and systems and controls units.

Prior to joining Crane Co., Mr. Huddleston was for 7 years Assistant Executive Secretary and Director of Public Relations of the Farm Equipment Institute in Chicago, including being director of the Pesticide and Application Equipment Manufacturers Association. He has had his own consulting firm on association management, public relations, and sales promotion.

Mr. Huddleston served for 9 years with the U. S. Department of Agriculture in the Great Plains and in Washington, D. C., and was with the Ware Publishing Company in Philadelphia as editor of the National County Agent & Vo-Ag Teacher and other publications. He also has a background in newspaper, advertising, and educational work.

Following his college work at Transylvania College and the University of Cincinnati, he served on the staff of the University of Kentucky for 1 year. He has taken organization seminar work at the University of Illinois, and organization studies at Northwestern University and Michigan State College. He received his Certificate in Organization Management from the National Institute of Organization Management, Michigan State University.

Mr. Huddleston is a past director of the Forum of Association Executives, past president of the Chicago Agricultural Club, a charter member of the Soil Conservation Society of America, and an Honorary Member, Future Farmers of America. He is also a member of the American Society of Agricultural Engineers; American Public Relations Association; National Press Club; Agricultural Relations Council; American Agricultural Editors Association; and, National Association of Radio and TV Farm Program Directors.

He and Mrs. Huddleston have three daughters, the oldest a Senior at Carroll College, Waukesha, Wisconsin.

L. J. Markwardt Honored by ASTM

L. J. Markwardt, retired assistant director of the U. S. Forest Products Laboratory, Madison, Wis., and a charter member of FPRS, was honored at the 63rd Annual Meeting of the American Society for Testing Materials in June at Atlantic City when he was presented with an honorary membership in the Society.

At the Forest Products Laboratory from 1917 until his recent retirement, Markwardt played a leading role in the research that advanced wood as an engineering material. He is author of numerous works on wood properties, timber design and construction, and test methods.

A member of ASTM since 1920, he has served as president, vice-president, and member of the Board of Directors, and he was active on numerous committees. He has received international recognition as an authority on forest products, and is currently chairman of the United States program committee for technical forest products for the 5th World Forestry Congress to be held at Seattle this year.

Ohio Valley conducts panel on polyvinyl gules: left to right, Robert Gill, moderator Carl Trinkle, and Elmer Bergey.

Harold Cook, acting chairman of the Ohio Valley Section, greets guests at the social hour.

Governor L. H. Hodges (standing) pays tribute to the late Brandon P. Hodges of Asheville at the dedication of North Carolina State College's new Wood Products laboratory. With the Governor are Dr. J. T. Caldwell, State College Chancellor (left); and R. P. Gravely of Martinsville, Va., president of Gravely Furniture Industries.

N. C. Wood Products Lab Named in Formal Ceremony

North Carolina State College formally dedicated and named its new $250,000 Brandon P. Hodges Wood Products Laboratory, May 25, in ceremonies attended by members of the Hodges family and wood industry and forestry leaders from throughout the Southeast.

Long a friend of State College, the late Brandon P. Hodges was a key figure in the development of several college facilities and programs, particularly in the fields of forestry, wood products, and pulp and paper technology.

Governor Luther H. Hodges, who made the address of dedication, declared, "From here will come both the personnel and the ideas that will continually stimulate and challenge your industry. From here will come the tangible and intangible seedlings that will, day to day, breathe new strength and vitality into your activities—breeding benefits that will be felt directly or indirectly by every citizen within the range of this facility influence."

The new Wood Products Laboratory is the only research facility of its kind in the Southeast and is regarded as one of the outstanding laboratories of its type in the region.

Basic objectives of the laboratory, college officials said, will be a quest for knowledge about the properties and uses of wood; to anticipate future needs of the wood-using industry and to conduct research designed to provide information required to meet industrial needs; to develop the processes and techniques required to develop new uses for wood, improve upon old uses and to develop techniques for converting wood into other useful products.

Groups Pledge Support For NFPW

Henry Clepper, Executive Secretary of the Society of American Foresters, announced recently at his organization's Board of Directors meeting in Grand Isle, Louisiana that the association will give its wholehearted support to National Forest Products Week.

The directors endorsed the program and recommended strong section and chapter participation in local activities emphasizing the important place of the forestry profession in managing lands to insure a permanent supply of forest products for the use and benefit of the American people. The Journal of Forestry, official Society publication, will publish NFPW news items and program activities during the coming months.

Forest Service to Assist

In response to an invitation from Hoo-Hoo International for United States Forest Service participation in NFPW, Richard E. McArdle, Chief Forester, offered his agency's assistance wherever possible. United States Forest Service activities for NFPW will be handled by Clint Davis, Director of Information.

AFPI Offers Help

In outlining the American Forest Products Industries cooperation in NFPW, Charles A. Gillett, Managing Director, has suggested that Tree Farm Committees schedule local Tree Farm dedications during the week of October 16–22.

Gillett also stated that through AFPI's district offices information of local and state tree farm activities can be channeled to industry representatives willing to use this material in speeches or other NFPW presentations.

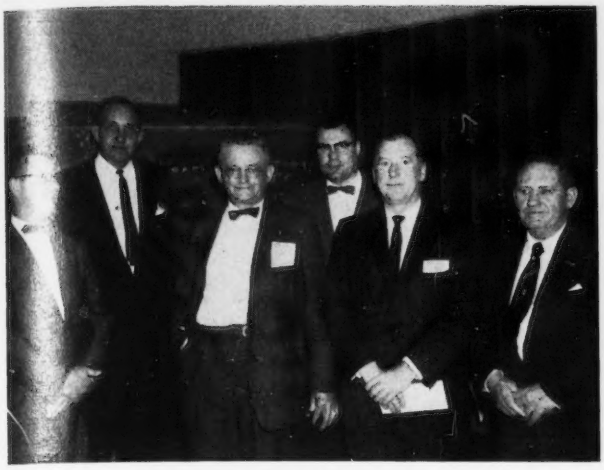
NEW OFFICERS: R. J. Hoyle, Jr., Chairman; C. M. Kreiter, Past Chairman; F. W. Varsveld, Trustee; W. G. Walker, Vice Chairman, and J. P. Howe, Secretary-Treasurer.

Inland Empire Officers Named at Spring Meeting in April

The spring meeting of the Inland Empire Section was held in conjunction with the annual meeting of the Northwest Wood Products Clinic in Spokane, April 12 and 13, 1960. New officers and trustees for the coming year are: Robert J. Hoyle, Jr., Potlatch Forests, Inc., Lewiston, Idaho, Chairman; William G. Walker, Pacific Power & Light, Portland, Oregon, Vice Chairman; John P. Howe, University of Idaho, Moscow, Idaho, Secretary-Treasurer; and Trustees—C. M. Kreider, Brooks-Scanlon, Inc., Bend, Oregon; H. R. Dix, Anaconda Co., Bonner, Montana; R. L. Jackson, Edward Hines Lumber Co., Hood River, Oregon; R. A. Crowe, Missoula White Pine Sash Co., Missoula, Montana, and F. R. Varseveld, Kootenay, Forest Products, Nelson, B. C.

Nicholson Mfg. Co. Opens New European Subsidiary

The Nicholson Manufacturing Company of Auburn, Washington has formed a European subsidiary it was announced recently by T. W. Nicholson, President. The new subsidiary, which will be called Nicholmaco, A.G., will sell and service equipment manufactured by the parent company throughout Europe, Africa, the Scandinavian countries and the Near East. Nicholmaco, A.G. will also act as sales agent for other American manufacturers of equipment for the forest products industry.



Participants in Ohio Valley meeting: left to right; Harold Cook, Henry Espel, William Lakamp, Phil Fenn, Jerry Habig, and John Wilson.

Ohio Valley Meeting included a tour of the Baldwin Piano Co., Cincinnati. Elmer Bergey, far right, looks on.

Ohio Valley Section Holds Spring Meeting

The Ohio Valley Section Meeting last April attracted some 50 members and guests to a 2-day session in Cincinnati.

The program included a discussion of properties and machining of hardboards by R. A. Bicknel, Masonite Corporation, Laurel, Miss.; a presentation on fan-air drying of lumber by W. J. Tomford, Fan-Air Systems, Memphis, Tenn.; a panel discussion on the uses and limitations of polyvinyl glue, with Carl Trinkle, Baldwin Piano Co., moderator, and Robert Gill, Peter Cooper Corp., Gowanda, N. Y., and Elmer Bergey, National Casein Co., Riverton, N. J., panel members.

The program also included films of new machine developments and a tour of the Baldwin Piano Co., Cincinnati.

FPRS Members to Take Part in NAFM Annual Meeting

Sprunger

Snow

Several members of FPRS will be active participants in the National Association of Furniture Manufacturers' 32nd annual convention, August 27–30 at Chicago's Conrad Hilton Hotel.

Harold Sprunger, Dunbar Furniture Corporation and NAFM's president, will be in charge of the meeting, which will stress the theme, "The New Approach for Marketing and Manufacturing in the '60's."

Said John M. Snow, Executive Vice President of NAFM and program planner for the convention, "Now that we're looking squarely and realistically at this decade, it shapes up as the 'highly competitive' '60's. Realizing that to meet this challenge, manufacturers are taking a hard look at operations to increase efficiency and reduce costs, our program will present a thorough and vivid presentation of the newest in production and management techniques."

W. Smith

Rucker

Walton R. Smith, chief, Division of Forest Utilization Research USDA, and membership chairman of FPRS, will participate on the panel in the Wood-Drying seminar. Panel members discussing the relative merits of fan drying and conventional kiln drying will be Carlton Smith, president, Carlton Smith Industries, Memphis; R. N. Elliott, Standard Dry Kiln Co., Indianapolis; and Tinsley Rucker, president, Dixon Powdermaker Furniture Co., Jacksonville, Fla., NAFM's first vice president. This panel will be moderated by Jack Whaley, publisher, Furniture Production Magazine, Nashville, Tenn.

Gatewood

Moser

Howard Gatewood, Fine Hardwoods Association executive vice president, will moderate a panel on "Finishield." Another FPRS member participating in this session is F. H. Thomas, Sherwin Williams Co., Chicago.

Moderating the sanding session will be A. L. Fader, A. L. Fader Machinery Co., Chicago.

The Wood Adhesive Program will be headed by Harold C. Moser, vice president, Gamble Bros., Louisville, Ky. Robert Gill, technical director at the Peter Cooper Corp., Gowanda, N. Y. and Dr. Thomas Cook, president, National Casein Co., Chicago, are the panel members.

Thomas

Gill

During the convention on Monday morning, August 29, the NAFM will hold its annual election of officers. A Las Vegas informal party, Monday night, replaces the association's annual banquet.

The exhibits of some 115 suppliers to the furniture industry will be opened officially at 12:00 noon Saturday, August 27. They will be open to manufacturers every day, thereafter, from noon until 6:00 p.m.

California Technologist Publishes In Encyclopedia

J. E. Marian, wood technologist in the University of California's Forest Products Laboratory at Richmond, and an active member of FPRS, has contributed a lengthy survey article on wood finishing to the forthcoming McGraw-Hill Encyclopedia of Science and Technology. The Encyclopedia, largest of its kind ever produced in the United States, will be published this fall in 15 volumes.

Marian's article is based largely on his extensive study of wood finishing problems at the Forest Products Laboratory and in Europe. It also summarizes the work of other experts in this field throughout the world. The UC scientist is credited with developing numerous technically and commercially successful wood finishing processes and has served as a consultant in many nations. He joined the staff of the Forest Products Laboratory in 1956 after working at the Swedish Forest Products Research Laboratory in Stockholm for four years, and is also currently acting as advisor to the National Council of Applied Economic Research of the Government of India.

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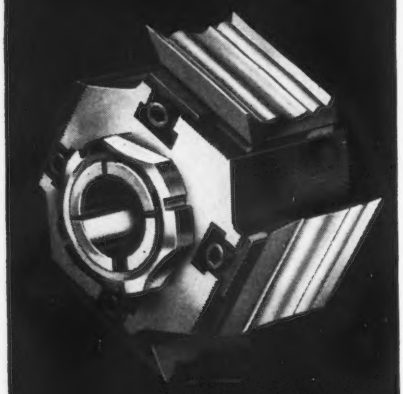

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Particle Board Association Holds First Meet in Denver

The newly formed National Particle Board Association held its first semiannual meeting in Denver, Colorado on June 2, 1960. All 16 companies, who are active members of the Association, were represented at this meeting.

The highlight of the meeting was announced by the President, David C. Greeley of the Weyerhaeuser Company, was the work of the Association Technical Committee with Paul McCormack of National Starch as chairman. Action programs developed by the committee and approved by the board include the following:

1. Finalization of industry commercial standards for particle board to be established with the Technical Standard Division of the Department of Commerce.

2. Development of special standards to cover particle board used for underlayment to be adopted by the industry as quality standards for performance in this important market.

3. Promotion of a symposium on particle board to be held at the Forest Products Laboratory at Madison, Wisconsin, later in the year.

Another Association program approved by the members include industry efforts to bring about reasonable tariffs on imported particle board, publicity, and active public relations work with various elements of the flooring industry such as tile manufacturers and flooring applicators.

Lumber Consumption Reported

National lumber consumption, including exports, was estimated at 8,608,000,000 board feet for the first quarter of 1960. This was 9.1 per cent below the preceding quarter and 3.4 per cent less than the figure for the first quarter last year, NLMA reports.

Consumption in the second quarter is expected to total 10,200,000,000 board feet, an 18.5 per cent increase over the first quarter but 7.9 per cent below the corresponding period of 1959.

Estimated national consumption in the first quarter was 1.1 per cent below production. This represented a change in the lumber picture. In the last quarter of 1959, consumption exceeded output by 3.6 per cent; in the first quarter last year, consumption was six per cent above production.

New Paper and Pulp Mill

Construction of the first paper and pulp mill in Arizona for the manufacture of newsprint and kraft linerboard is under way it was announced recently by J. B. Edens, president of Southwest Forest Industries, Inc.

Located near Snowflake, in the east central part of the state, the mill will cost in excess of $32 million to build and equip and will provide employment for about 800 people. It will produce 75 thousand tons of newsprint and 65 thousand tons of kraft linerboard and paper annually. Mr. Edens estimated that the kraft portion of the mill would go on stream in October, 1961 and that newsprint would be produced by December, 1961.

Philippine Lumber Assn. Names Officers

The Philippine Lumber Producers' Association announces the names of its officers and members of the Board of Directors elected during the Annual Meeting of the members held March 15, 1960, in Manila.

Former House Speaker and Finance Secretary, Hon. Antonio de las Alas, representing the Cantilan Lumber Co., is president of the organization. The other members are Carlos P. Fernandez, Nasipit Lumber Co., 1st Vice President; Gaudencio E. Antonio, Western Mindanao Lumber Co., 2nd Vice President; and Pacifico de Ocampo, Secretary-Treasurer and Legal Counsel.

Members of the Board are Florentio Tamesis, Anakan Lumber Co.; Nicolas Capistrano, Jr., Misamis Lumber Co., Jose G. Sanvictores, Aras-asn Timber Co., P. M. Picornell, Bislig Bay Lumber Co., Richard S. Kearns, Insular Lumber Co., and Leonides S. Virata, Aurinaldo Development Corp.

New Resin Plant for South

National Polychemicals, Inc., Wilmington, Mass., announces that it has begun operations at its plant in Conway, North Carolina. The new plant will produce urea and phenol-formaldehyde resins for the South.

The new Southern units is under the direction of L. F. Bornstein, Vice President in charge of the firm's Synthetic Resin Division. According to Dr. Bornstein, National Polychemicals has also expanded its Wilmington, Mass., facilities to take care of needed increased production of resins in New England.

Woodmen's Carnival Planned

The 9th annual Penn-York Woodsmen's Carnival, the biggest event of its kind in the Northeast, will be held Aug. 5–6 at Cherry Springs State Park in Potter County, Pa. The carnival features exhibits of more than a million dollars worth of logging and sawmilling equipment, and a series of logging contests with the best woodsmen of the Northeast competing. The carnival is the major event for the Penn-York Lumbermen's Club, an organization of men from lumber and related industries from Pennsylvania and southern New York.

The purpose of the carnival, according to B. E. Kramer of Galeton, Pa., general chairman, is "to give woods workers an opportunity to display their skills in competition and to dramatize the importance of the area's timber industry." The area, he pointed out, produces in the vicinity of a billion board feet of lumber yearly and thousands of cords of pulpwood. Most of the lumber is high quality and high value hardwoods.

Test Service For Plywood Mills

Enough plywood for 400,000 new houses —about one-third the annual rate of housing starts in recent years—will be produced in 1960 by the 10 Western softwood plywood mills subscribing to the quality control testing service offered by the Timber Engineering Co., NLMA affiliate.

Bin Box Brochure Published

A new publication on the subject of bin ...xes was introduced to members of the ...ational Wooden Box Association at its ...mmer meeting held at The Homestead, ...t Springs, Va., this June. This brochure ...tlines the advantages and limitations of ...terials handling in bulk containers in in...stry and agriculture. Various types and ...les of bin boxes are described, and the ...fferent factors which must be taken into ...count in designing the proper bin box ...r a particular application are outlined. ...e booklet will be available to user or...nizations through individual box ...anufacturers.

AITC Forms Inspection Bureau

The formation of an Inspection Bureau and the appointment of T. E. Brassell, as the first director of the new bureau, were announced here today by F. J. Hanrahan, executive vice president of the American Institute of Timber Construction.

During the last two or three years the industry has been developing a quality control and inspection system for the manufacture of structural glued laminated timber and the fabrication and assembly of structural timber framing. It is anticipated that the AITC certification and quality marking will be made available to customers within a year.

Lumber Residues Put to Use

A survey just completed by the Western Pine association's research department discloses that of 5,484,000 tons of residues, or "leftovers" developing in a year at the 12-state region's lumber mills, 3,444,000 tons are put to use as pulp chips, fuel, agricultural soil helps, wood flour, briquettes and various small lumber products.

The statistics showed the region's 1959 lumber production at an all-time high—nearly twice the 1940 pace—while unused residues were at a record low, and apparently dwindling further each year. Scores of mills have dismantled their burners.

In the unused residues class, available for new by-products industries, the survey found 2,039,000 tons a year. At the same time, used residues included 2,512,000 tons for fuel and 933,000 tons going into various products. In other words, only about one-third of the wood volume left over after lumber manufacture, including sawdust and shavings, failed of utilization. Weights were computed on a "bone-dry" basis.

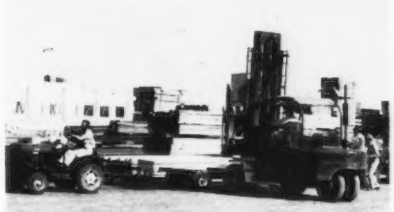
Carl A. Rasmussen, director of research, termed the findings "an eye-opener for the 'waste criers' while at the same time they point to a fine opportunity to create more new jobs and new products through still closer utilization."

"We have no way of estimating how many jobs are based on, and how many new dollars are created for the economy by the productive use of 3½ million tons of mill residues," he said, "but surely the progress made in utilization is impressive, and beneficial to the West as a whole."

NEW PRODUCTS and Literature

New Cut-Off Saw

The No. 606 Bee-Liner, the latest addition to the Ekstrom, Carlson line of machines, can be either manually or power operated. Automatic cycling, with 60 short ram strokes to 20 long ram strokes per minute, makes the Bee-Liner fit in with plant automation—increasing production, lowering costs and reducing operator fatigue. Perfectly balanced, light weight, air operated head rides on precision ball bearing races assuring smooth, accurate and easy operations. Has powerful shell-type, fan cooled motor with self-contained 1⅛ inch diameter arbor running on shielded, double row, deep groove ball bearings. For complete details, accessories, prices and applications write for Bulletin 606. *Ekstrom, Carlson & Co.*, 1400 Railroad Avenue, Rockford, Illinois.



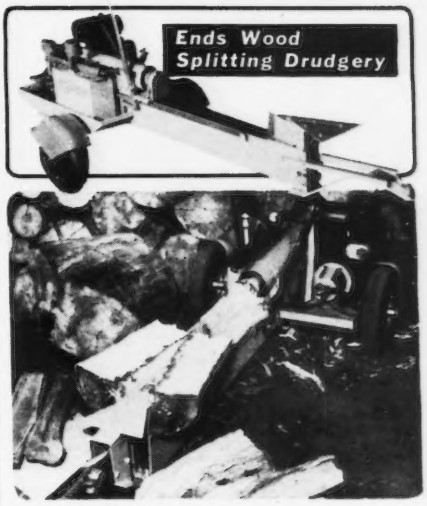
Western Lumber in New Site

Western Lumber Company, one of San Diego County's pioneer lumber suppliers, now is in operation at the new location, 2745 Tidelands Avenue, National City, adjacent to San Diego, according to J. D. Sullivan, Vice-President and General Manager.

The new area of Western Lumber Company covers approximately 14 acres, with additional land adjoining for future expansion. Cost of the new plant is estimated at $750,000, exclusive of inventory and rolling stock.

The Company's products include lumber in its many types and varieties: Douglas fir timbers, structural and clears; cedar and pine, plywoods; also the largest inventory of California Redwood in San Diego County. The new plant is capable of handling full mill bids, including skilled cabinet work.

LICKITY LOG SPLITTER



Hydraulic POWER SPLITS PROFITS from WASTE WOOD

- 7 H.P. Trailer Model
- Two Speeds
- Automatic Shift
- 18 Ton Force
- Automatic 26-Inch Stroke
- 2 Models Handle Logs Up to 30" and 48" Length, Any Diameter
- Power "Squats" to Take Large Diameter Logs Without "Dead" Lift

If you are in the cord wood business . . . or have wood available but hesitate to split it because of the labor involved, then a Lickity Log Splitter is your answer to a profitable business without the splitting drudgery.

Lickity Log Splitters are in use in all sections of the country. Many owners report the sale of from 300 to 600 cords of wood split in spare time. It's a profitable investment. Your name on a post card will bring literature and name of your nearest dealer.

THE WACO AIRCRAFT CO.,
Dept. S., Troy, Ohio
Dealer Inquiries Invited

NAMES in the NEWS

Robert E. Dougherty of Silver Springs, Md., has been named Executive Director of the National Particleboard Association. In announcing this appointment, **David Greeley,** President, stated that Mr. Dougherty assumed his new duties as of June 1, and participated in the Semi-Annual Meeting of the Association held in Denver, June 1 and 2.

Appointment of **F. G. Owen, Jr.** as Manager of Creosote Sales, was announced by **J. C. Macon, Jr.,** Sales Manager of Koppers Tar Products Division. In his new capacity, Mr. Owen replaces R. O. Hawes, who is leaving Koppers to become General Manager of the AWPI, Chicago.

R. J. Lodge, General Manager of the Resins & Chemicals Department of the Borden Chemical Company, reports the appointment of **Thomas L. Trafford** as Engineering Manager for that department. In his new job, Mr. Trafford will be responsible for all phases of the department's engineering requirements at the Bainbridge, N. Y., Browntown, Wis., Demopolis, Ala., and Fayetteville, N. C. plants.

Benjamin J. Skowronski has been named Manager, Midwestern Sales, by National Polychemicals, Inc., Wilmington, Mass. He will make his headquarters in Akron, Ohio. Before his new appointment, Mr. Skowronski had been technical service representative for the Neville Chemical Co.

The West Coast representative of the Hurlbut Paper Company of South Lee, Mass., is **Lester L. R. Phillips,** Assistant Sales Manager. His headquarters will be in the Mead Packaging Plant at 2726 Fruitland Avenue, Los Angeles.

Ted Krauth, of the Tri-States Spray Equipment Co., 1118 Farnam, Omaha, Neb., has been appointed factory representative for the driQuik line of ceramic-type electric infra-red industrial drying ovens. The ovens are manufactured by the Dry Clime Lamp Corp., Greensburg, Ind.

Max Merz, engineering consultant for Atkins Saw Division since 1958, has been named West Coast Manager of the Saw Chain Division of Atkins Borg-Warner, Indianapolis.

Rudolph Kemppainen has been appointed saw chain salesman for Atkins Saw Division, Borg-Warner Corp., Indianapolis. His territory will consist of Illinois, Missouri, Nebraska, Kansas, Oklahoma and Arkansas.

Irving Fischer has been promoted to New York district sales manager, National Starch and Chemical Corporation, and has assumed additional responsibilities. In announcing this change **Lester Klempner,** Assistant Vice-President and Eastern Regional Sales Manager, pointed out that Mr. Fischer will now supervise resin sales in addition to adhesives sales.

EMPLOYMENT Opportunities

Positions Offered

E-399—Teaching-research position in wood products in accredited forestry school in Midwest University. Teaching during one semester only in wood technology, seasoning, and preservation. Full-time research during one semester and summer. Appointment probably as assistant professor, but rank and salary commensurate with training and experience. (August)

Employment Wanted

613—Prof. Engr. (Cal. Tech.) B.S., M.S. Mech. Engr. Been in top management 13 years in furniture, cabinet, fixture and architectural, door, machinery and grain printing plants, looking for top job or wishes to represent Eastern manufacturer on the West Coast. (July)

614—Wood technologist with five years laboratory, field service experience with large adhesive company. Wants development or production work in particle board or other forest products industry. B.S. in Forestry, M.S. in Wood Utilization. Age 32. (July)

615—Wood Technologist soon to receive Master's Degree desires position in basic wood drying research. Experience includes several wood drying studies and thesis work. Primarily concerned with stresses and their removal. Will be available beginning in September. Secondary interest in wood quality-tree growth studies or particle board research. Strong background in forestry. (July)

616—General foreman, superintendent, or quality control manager position desired by graduate in Wood Utilization with B.S. degree from Iowa State College. Two years' experience in quality control and production. Familiar with lab testing, millroom equipment and procedures. Age 26, married, 1 child. (August)

What's New in Technical Publications

Single Copies of the Following Reports are Available Free Upon Request from the Director, U.S. Forest Products Laboratory, Madison 5, Wis.

A new report, **"Heating Veneer Bolts to Improve Quality of Douglas-Fir Plywood," No. 2182,** is one of six new or revised reports recently issued by the U.S. Forest Products Laboratory here. It describes three methods of heating Douglas-fir bolts to improve veneer quality and discusses the advantages and limitations of each.

Report No. 2184, "Feed-Speed Relationships for Cutting Tools," explains the use of a chart, included with the report, for computing the interrelationships between the number of cutting edges of the tool, its speed, and the feed per cutting edge or per minute.

A discussion of groundwood and sulfate pulping experiments made on wood from pole-blighted and healthy western white pine is contained in a report, **"The Groundwood and Sulfate Pulping of Pole-Blighted and Healthy Western White Pine," No. 2185.**

A report entitled **"Your Career in Forest Products Research," No. 2186,** highlights some of the opportunities, advantages, and qualifications for the individual considering a vocation dedicated to scientific research in the forest products field.

Report No. 2183, "Symposium on Adhesives for the Wood Industry," contains the proceedings of a symposium that was sponsored jointly by the Forest Products Laboratory and the Products and Research Committee of the National Lumber Manufacturers Association on January 13–15, 1960.

A revised listing of publications that give general information and research results on the growth, structure, and identification of wood is contained in Report No. 177.

TEACHING POSITION

University in Inland Northwest requires Wood Technology / Forest Products teacher. Initial duties principally to teach broad range of undergraduate courses. Future involves expanded graduate program and research activities. Desire man with Ph.D., preferably with above average background in chemical aspects. Salary and rank dependent on qualifications and experience. Please send resume of education, experience and personal data.

Send replies to:

E-398, Employment Service
FOREST PRODUCTS RESEARCH SOCIETY
417 North Walnut Street
Madison 5, Wisconsin

HELP WANTED

DAVID R. WEBB CO., Edinburg, Ind. veneer manufacturers, has an opening for an assistant plant superintendent, thoroughly familiar with VENEER production.

Also for a manager for the newly created LUMBER department, familiar with all phases of lumber production and sales.

Write age, qualification and expected salary, to the attention of Mr. Michael Joelson.

All correspondence will be held in strict confidence.

THE FOREST PRODUCTS RESEARCH SOCIETY'S

Official Publication Policy

Approved by the Executive Board
June 9, 1960

1959–60 PUBLICATIONS COMMITTEE

EDWARD G. LOCKE, *Chairman*	S. B. PRESTON
E. A. BEHR	A. D. SYSKA
DAVID L. BRINK	F. F. WANGAARD
J. B. HUFFMAN	R. W. WELLWOOD
I. H. ISENBERG	R. F. WEST
H. B. MCKEAN	W. I. WEST

Publications Committee in session: S. Preston, D. Brink, E. G. Locke, R. W. Wellwood, and W. I. West.

THE PUBLICATIONS OF THE FOREST PRODUCTS RESEARCH Society constitute its most valuable and lasting service to its members and the future of the wood-using industries. It is therefore important that guiding policies be laid down so that the publication efforts of the Society be of a consistent, high quality.

Because of the importance of these policies, however, it is also necessary that they not be arbitrarily set, but that they evolve from a few basic starting points as a result of problems, experience, and discussions. This process of evolution has brought the Society to a point now where a statement of overall publication policy, as it now stands, is warranted. This policy will no doubt continue to evolve. Minor changes will occur, and perhaps some major mutations, as the Society grows in membership and stature.

The Forest Products Journal as it now exists has developed into the main medium for the publication and dissemination of the results of research and development for the forest products industry. With an attractive new cover and pleasingly modified format, the Journal represents much progress already from the early Proceedings of the Forest Products Research Society published in the late 1940's, and the more refined Journal of the Forest Products Research Society, which was supplanted in 1955.

Content of The Journal

Progress has come not only in appearance, but in the variety and overall quality of the editorial matter printed. Where early issues of the Proceedings contained the papers presented at the year's National Meeting, session by session, the current Journal maintains a careful balance of fundamental research papers on the one hand, and practical, production-type articles on the other. Further balance is achieved through attention to the various subject-matter categories represented by the Society's Divisions.

This matter of editorial "balance" has received much attention from the Publications Committee and the Executive Board. The present policy is that, in a typical issue of the Journal, approximately half the articles should be of a fundamental, while the remainder should be of an applied nature. There will be variations in specific issues, of course. Because the technical papers tend to be longer than the applied papers, more than 50 percent of the total article pages will contain technical information according to the present policy. This is at least partially compensated by the practical nature of many of the departments of the News-Digest and other features of the Journal, including the advertisements.

The balance of subject matter is also an important consideration. A typical issue of the Journal contains 10 or 12 articles. Balance of subject matter is determined to a large extent, obviously, by the activity of the Divisions in the presentation of papers at the various meetings of the Society. The reviewing procedure also complicates the availability of submitted papers, but this will be discussed more appropriately under another heading. An additional item of policy on the subject of "balance" concerns feature or special issues. At the 1958 National Meeting in Madison, the Publications Committee went on record as favoring occasional issues where several significant articles on one subject, such as wood preservation, would be featured. The Committee stipulated, however, that the featured subject should include no more than half the papers published in the issue. The February Annual Review issue does not come under this feature classification.

To be an effective organ within the Society, the Journal must carry other types of information in addition to technical and applied papers. Advertising, within the interests of the Society, not only provides valuable information to members in industry, but also helps defray the expense of printing the Journal. Continuing the department "Abstracting the Literature" has been debated on numerous occasions, but it has received strong support from both research and production men. "World Wide Forest Products News" supplements the abstract section on an international basis, and in a more current, readable fashion.

The "News-Digest" serves the primary function of disseminating internal news of the Society to its members. Stimulating interest in coming events and describing past meetings are among its goals. It provides additional services in publishing employment opportunities, new-product releases, personnel changes, plant expansions, and so forth. The News-Digest holds an important place in the publications of the Society. However, the material should be news—not rewrites of readily available information.

Reviewing Submitted Papers

All papers presented before the various meetings of the Society are the property of the Society and automatically are considered for publication in the Journal. The term "considered for review" has slightly different meaning for National Meeting papers and Section Meeting papers . . . National Meeting papers are first to be approved by the chairman of the division arranging for presentation of the paper, or by a representative designated by him. Section papers are to be reviewed by the regional reviewer designated by the Publications Committee. This review in either case is considered to be a preliminary one to determine subject-matter applicability and quality, and does not replace a later technical review by technical critics. Papers rejected by the division chairman, his designated representative, or a regional reviewer are returned immediately to the author for his disposition. Otherwise, following the preliminary review, the papers are sent to the editor of the Journal who then selects two

If the reviews are favorable, the paper is published as submitted, or with minor modifications suggested for the author's consideration. If the reviews are unfavorable, the paper may be rejected, abstracted, or published after major revision by the author. Papers that are rejected are returned to the author through the appropriate section or division chairman, with the reason for rejection, and possible suggestions for publication elsewhere. Papers submitted for publication without presentation at a meeting are returned directly to the author.

Competent reviewers for papers in the various subject-matter division were originally selected by the Publications Committee. The Publications Committee may add to the reviewing staff those persons who have demonstrated their technical competence in a particular field through their publications or other contributions.

The reviewers in the appropriate field should be as unbiased as possible and able to give a thorough objective criticism of the paper. The reviewer may elect to remain anonymous. He evaluates the paper along the lines shown in the reviewer's record form.

If the two reviewers disagree, the editor of the Journal should refer the paper, along with the reviewer's report, to the Publications Committee for final decision.

Prior Publication

Because of financial limitations under which the Journal must operate, only original material may be published. Papers that have appeared elsewhere in print, regardless of value, cannot be considered for the Journal, unless they are papers published in a language other than English or preprints distributed at a meeting.

This limitation of prior publication precludes an FPRS author from releasing his paper to another magazine before it appears in the Forest Products Journal. Again it should be emphasized that any paper presented before a meeting of the Society and any paper submitted to the Journal for publication become the property of the Society. Such papers cannot be released without the permission of the Executive Secretary, under policies established by the Executive Board. The purpose of this is not to restrict dissemination of material presented at FPRS meetings, but to protect the integrity of the Journal. Actually, any representative of the trade press is free to request any papers from the Executive Secretary, and he is free to print the material at any time, subject only to the limitation that the editorial content of the paper must be condensed to not more than half its original length.

Scheduling Articles for Publication

The date an article appears in the Journal is primarily a function of when it is submitted or presented. The length of time between submission and publication may be lengthened or shortened somewhat by the influence of such factors as timeliness, subject matter, source, and reviewing complications.
qualified men for the technical review of the papers to determine if they shall be published in the Journal. The elapsed time these papers are in the hands of the reviewers should be kept to a minimum.

National Meeting papers have general priority, other factors being equal, followed by Section and contributed papers not presented before a meeting of the Society. Papers presented before a meeting of the Society shall have a footnote stating the meeting and the date presented. All papers shall show the date received by the editor for publication. All National meeting papers approved for publication are to be published within four months following the National Meeting insofar as possible.

The factor that causes most difficulty in scheduling, however, is the reviewing process, and the delays associated with revisions nessitated by criticisms. Even after a paper is scheduled for publication in a particular issue and has been set in type, physical limitations that arise in layout of the pages may delay printing for a month or two. These factors, plus editorial balance, must be considered by the editor, who must use his own discretion in deciding which papers warrant preference over others so that each issue will merit the greatest attention from the largest number of readers.

Editing of Papers

It is in the editing of papers to meet FPRS standards of quality, grammar, and style that the editor evokes most criticism from sensitive authors, and must stand on his own professional ability. Fortunately, for his sake and that of the authors, some rules have been laid down for guidance in the publication, "How to Write for FPRS," copies of which can be obtained from the National Office. Format and typography, however, often dictate changes in title, sequence of illustrations, which must be settled between author and editor. Editor's changes shall stand unless the author can show that intended meanings have been changed or obscured. The format of the Journal has been constantly evolving over the past few years, and some authors may object to having the titles of their papers reworded to fit current format. If the editor did not have the authority to make such changes, however, progress would be stifled and the Journal would not continue to improve.

There are several points in editorial policy that are clear cut, such as the rule against the unnecessary use of trade names. The generic term should always be used rather than the trade name of the product manufactured by the author's company. If there is no established generic name for the product being discussed, it should be described in detail with appropriate patent references and so forth so that the information that follows can be completely understood and thus be of use to the reader. Acknowledgements are not printed under such a heading in full-size body type. If an acknowledgement for professional assistance is necessary, it is handled in small type as a footnote, either from the author's name or from an appropriate place in the text. Such things as assistance in preparing test specimens or samples, carrying out routine tests, and reading or typing manuscripts are not acknowledged in the Journal. Suitable recognition of junior authorship and cooperation between agencies or companies will, of course, be handled in an appropriate manner.

After papers have been edited for publication, they are set directly in type. The galley proof is then sent to the author who has the responsibility for reading them. He can correct errors but suggest only the most necessary changes at that point. Changes on proof are costly and time consuming, since the editor must be alert to further errors introduced when the printer replaces lines of type. The editor against must decide which changes must be made. Additions of more than a few lines, for instance, may not be possible because of physical limitations of the space allocated to the paper. The editor works on very close deadlines, and once the sequence of papers in an issue has been worked out and space allocated, changes to accommodate one author cannot be made unless the need is critical.

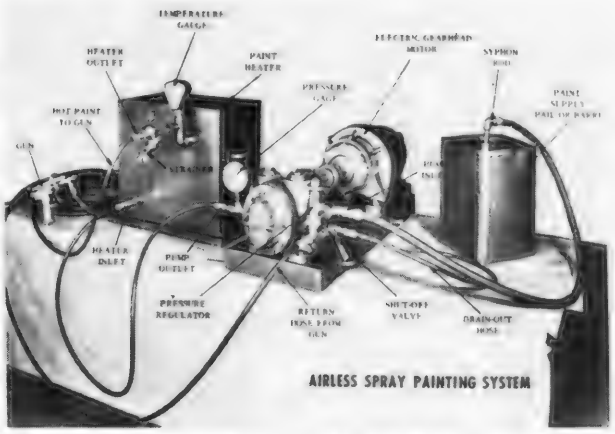
In laying out issues of the Journal, it occasionally is necessary for the editor to cut small amounts from an article to meet space requirements. This is a delicate task, undertaken only when absolutely necessary. In fundamental papers, this is normally limited to rewording a few sentences to pick up short lines on final page proofs after layouts have been made. With general papers, somewhat more may be deleted. This trimming of length not only makes the Journal more pleasing and professional in appearance (by eliminating small amounts of text that would otherwise be carried over to the top of an additional page), but may also make possible a significant saving in the cost of reprints, if ordered. Reprints may be ordered any time within the month after the month of publication. The cost depends on the number of pages to be reprinted, and is indicated to the author when he receives his complimentary copy of the Journal.

Grievances

Although such occurences are extremely rare, a problem sometimes arises that cannot be solved by normal communication between editor and author. The author may then follow a grievance procedure until the matter has been satisfactorily settled. This sequence would involve contacting, in the listing order: the Chairman of the Publications Committee, who may poll his Committee if necessary, and the President of the Society, who may poll the Executive Board if necessary.

FPRS FOREST PRODUCTS JOURNAL VOL. X, NO. 7 JULY, 1960

SEA-SIDE EXPOSURE racks used to investigate durability of experimental coatings for wood.



AIRLESS SPRAY-PAINTING system used to apply heavy organic coating films from hot-melt or heated systems.

Research on Wood Finishes

B. G. BRAND, L. J. NOWACKI, and H. N. JOHNSTON
Battelle Memorial Institute, Columbus, Ohio

RESEARCH ON WOOD FINISHES CAN be divided into three main types: development of new colors, improvement in methods of application, and increase in the performance of the coating.

The development of new colors is allied quite closely with marketing and trends in the tastes of the buying public. It is, therefore, largely a matter of conducting a continuous market survey to determine what Mrs. Housewife desires, followed by attempting to keep one step ahead of her, and have what she wants when she wants it. As long as compatible color systems are used throughout, the preparation of a new color is usually not difficult.

The Authors: B. G. Brand, Assistant Chief of Organic Coatings Research, has conducted coatings research for more than 2 decades; L. J. Nowacki holds BChE and MS degrees from Ohio State University, and has been associated with numerous research and development programs; H. N. Johnston, in coatings research for 10 years, has helped to develop both functional and decorative coatings for wood and other materials.

Investigators working on (1) basic research, (2) raw materials development, (3) improved coating formulations, and (4) improved end-use application are pointing toward the ever elusive goal of continual improvement of finishes for wood.

Developing new and improved methods of application to give more complete coverage and better general appearance is frequently a mechanical engineering development of an idea, and has occupied the attentions of many people for long periods of time. Improved application of finishes leads to more appealing, and frequently, more durable surfaces.

The major role of the coatings chemist, however, is the improvement of the performance of finishes. Performance is understood to encompass many qualities of organic finishes. Such items as improvements in application properties, gloss, leveling, temperature and chemical resistance, mar-proofness, scuff or scratch resistance, color retention, and outdoor durability fall within the scope of studies to improve performance of finishes for wood.

Four major fields of wood finishes, each having its own set of conditions to be encountered, and properties to be obtained are:

1. Exterior wood finishes
2. Floor finishes
3. Furniture finishes
4. Marine finishes

Of course, the above four fields are broad and encompass many different types of finishes. They, therefore, can and will be further broken down later into subgroups. For simplicity, each field will be discussed separately. Although considerable overlapping and duplication might be expected, it will be avoided where possible.

Exterior Finishes For Wood

This field is probably the largest and most complex of the four major fields of wood finishes. Subgroups can be identified as follows:

1. Outside house paints
2. Trim and trellis paints
3. Shake and shingle paints
4. Shingle stains
5. Barn paints

[1] Presented at Session VII, Wood Finishing, FPRS 14th Annual Meeting, June 7, 1960, in Montreal, Canada.

6. Lawn furniture paints
7. Exterior varnishes, porch and deck
8. Redwood finishes, clear
9. Wood preservation or preservative coatings

Research in each of these fields is continuing in the direction of improved durability. Certain trends in each of the subgroups can be noted, as follows.

Outside House Paints: Paints based on linseed oil as the vehicle continue to be quite popular for painting the exterior of wood houses. However, considerable investigation and promotion is going on regarding emulsion or water thinnable paints for outdoor use.

Resins being used successfully are the acrylic, acrylonitrile, polyvinylacetate and styrene-butadiene polymers in emulsion form. Certain problems are being encountered, particularly in application over surfaces previously painted with oil-based paints, but some progress is being made in solving this problem. Some companies are promoting the use of long-oil alkyds, particularly alkyds based on isophthalic acid, at a premium price, with promises of increased durability. Since the greatest part of the cost of painting a structure is the labor cost, an economic advantage can be shown for a premium paint with increased durability. Among other resins receiving some attention are vinyls, polyesters, styrenated alkyds and polyurethanes, although their high cost imposes a limitation.

Trim and Trellis Paints: These paints are usually required to have the same properties as outside house paints, but in addition they must not cause staining. This means that decomposition products of the paint, when washed down over areas of another color, usually white, should not discolor the second area. Long-oil alkyds are particularly useful in this area. Again, other more expensive resins are receiving some limited consideration. Control of chalking appears to be one of the mort important properties in decreasing staining, along with the avoidance of certain chemical ions, such as copper. Both of these involve the selection of proper pigmentation, as well as the resin component.

Shake and Shingle Paints: The problems with shake and shingle paints are largely identical with those of outside house paints. In fact, the major portion of shake and shingle paints is specially formulated house paints, modified to give good durability over cedar wood, and to have lower viscosity to give increased penetration.

Shingle Stains: As the name implies, shingle stains are solutions of dyes or coloring matter suspended in a very thin solution of a drying oil. The main purpose of shingle stains is to develop color for the wood without greatly altering the physical appearance. Linseed oil is normally used for the vehicle. Included in the oil is usually a significant amount of creosote, which acts as a wood preservative. Some work is going on in the search for improved preservatives, but the relatively low cost of creosote, coupled with its effectiveness, makes it hard to beat.

Barn Paints: The major requirements of barn paints are low cost and good protection. A few years ago, the color was almost universally red. In recent years, with the farmer becoming more sanitation conscious, white has become much more popular. Low-cost house paint formulations are the most popular, since the requirements are easily met with this material. Some work is proceeding in developing insect repellent coatings, to combat the fly nuisance. Several barn and dairy paints have been merchandised containing such materials as D.D.T., which help to control the fly menace. These materials are used for barn and dairy interiors.

Lawn Furniture: Although there is a relatively small market for paints for wooden lawn furniture, these coatings have received considerable attention with the increase in interest of "outdoor living". Where the natural beauty of the wood grain is desired, a clear varnish is usually applied over the properly stained, sealed, and filled wood. Many of the problems of marine finishes are found in this application. In fact, a good, clear marine finish is frequently used.

However, where opaque color is desired, high-gloss air drying enamels are usually preferred. These enamels are normally made from medium-oil length soya alkyds, and they may be modified with small amounts of rosin or phenolformaldehyde resins to improve their durability. Of course, the highly durable baked finishes are not applicable here, since wood furniture cannot be baked at temperatures much above 140° F. without injuring the wood.

Exterior Varnishes: Porch and deck varnishes have long presented a serious problem. The so-called "spar varnish" represented a big step in obtaining improved performance. This varnish was prepared from linseed oil and a phenolformaldehyde resin. Since that time, many improved materials have been developed that give even further increased performance. Some of the materials now being used are medium-oil length alkyds, styrenated alkyds, and such catalyzed systems as epoxy-phenolic and polyurethane resins. The recent trends appear to be toward the latter two materials.

Clear Finishes: A very special problem exists in clear finishes for redwood. The natural beauty of this wood makes a clear finish highly desirable. The most promising material to date has only limited durability. A unique type of failure is encountered with practically all coatings. Failure is by the development of many very fine cracks, that turn the coating white and render it almost impossible to refinish without removing all the coating down to bare wood, and starting over. This process is very difficult, lengthy, and expensive. Much work still needs to be done to develop a satisfactory clear finish for redwood. The failure is apparently due to a large difference in the expansion coefficients of redwood and any coating applied over it. Any attempt to plasticize coatings for this use apparently results in loss of other desirable properties. Intense work is going on currently in this field, and some of the more recently developed resins appear to have promise. For example, the Golden Gate Club of the Federation of Societies for Paint Technology in conjunction with the California Redwood Association have shown that clear oil-modified alkyds appear to have the best durability of those materials studied, but refinishing problems, as discussed above, were serious. In summary, no really satisfactory material has been found as yet, but the search is continuing, and it is hoped success will be attained in the near future.

Preservative Coatings: Wood preservatives are not usually considered to be wood finishes. Nevertheless, some consideration should be given to them, since it is often necessary to apply finishes over wood that has been preserved. The usual preservatives, particularly creosote, make finishing of the wood to which they have been applied difficult. Some research is being conducted on preservatives that are more compatible with coatings, and even on coating systems containing improved preservatives, making it unnecessary to impregnate the wood.

Protection of large timbers, such as those used for railroad trestles not only includes preservation of the wood from exposure to the elements, but protection against fire. In this case an intumescent agent that foams the paint film on heating is included

is type of coating. More efficient i tumescing agents are constantly be- i g sought. Isano oil is now being i ported and used for this purpose.

In fact, fire-retardant paints for ·od are used for many applications, h th external and internal, and are h ing studied for further improve- r nt. For example, it is believed by s ne people that intumescent or foam- i g coatings are very good protection a ainst radiation damage.

Clear Protective Floor Finishes

A wide variety of resinous type n terials are available and are being u d to produce clear floor finishes f r use in both residential and com- m rcial buildings. The chief difference b tween these two is that the coatings used in commercial buildings usually have to meet more rigid specifications than the finishes currently used by the "do-it-yourself" trade, although this latter group would also like the better materials. This is particularly true because of the preparation and inconvenience that is necessary prior to and during the finishing, or refinishing, of a floor.

Three Classes: Current floor finishing products usually utilize one of three well-known types of materials, each representing a relatively specific class of film-forming polymers. The first of these is shellac, a natural occurring raw material of animal origin. Products containing shellac are fast drying, easy to repair, and have an excellent appearance. The second class of materials is varnishes and alkyds that dry by an oxidative-polymerization process. These products have good durability but require longer drying time than other types of finishes. Finally, lacquer materials, which contain nitrocellulose, are still finding wide acceptance, especially in the refinishing trade sales field.

Desired Properties: Because of the large market for clear floor finishes and the emphasis in decorating to display beautiful woods, a considerable amount of work is being directed towards improving or developing products for this application. Some of the properties that appear to be the most important are fast dry, good color and color retention, hardness and abrasion resistance, water and chemical resistance, and, of course, all the properties needed for easy application. Needless to say, products that begin to meet these requirements will also be useful for many other wood finishing problems, including the "do-it-yourself" and the industrial finishing of furniture.

New Products: Present research, to bring about new products, has taken a number of different approaches with varying degrees of success. The first approach is concerned with improvement by chemical modification or the use of additives. This approach has been used in the case of all three types of materials presently used. Addition of ultraviolet absorbers to these materials usually improves the quality of the overall finishing job by reducing yellowing of the underlying wood during long exposure to sunlight. Chemical modification of shellac and oils has also brought about floor finishing materials with reportedly improved properties. Specifically, oils that have been modified with urethanes or epoxys result in products having faster dry and better resistance to chemicals and wear. More basic research on oils, such as investigation of the mechanism of their drying and failure, may give further specific ideas for improving properties of the starting products. One novel and interesting product to come out of similar exploratory work is an alkyd or oxidizing finish that drys in less than 10 minutes.

The other approach to this problem is through the development of new materials or the use of new concepts in application and formulation of the products. At the present time this type of research falls into two general categories. They are (1) the use of a two-part system and (2) a study of emulsion or water-dilutable clear finishes for wood. During the last few years, the general public has become more technically minded and, therefore, more willing to be a "pseudo" chemist and mix a two-component finish to obtain a superior product. A number of such coatings are gaining acceptance, especially in the industrial-floor-finishing field. These are polyurethane and epoxies, as well as amino-alkyd combinations. All of these finishes offer improved chemical resistance and excellent hardness and toughness, but they are somewhat difficult to handle because of solvent odors and limitations imposed by short pot life. They also pose some repairing and patching difficulties that are not encountered when shellac or lacquer materials are used.

UNIFORM FILMS of organic coatings can be applied by use of film transport.

ONE METHOD of applying an experimental coating to a continuous web of paper.

Special Emulsions: Because of the wide acceptance of water-dilutable paints and coatings in so many areas during the last decade, clear floor finishes have become another target of this class of materials. A wide variety of commercially available emulsions based on materials such as acrylics, styrene butadiene, and vinyls are available. Even greater opportunities exist through the polymerization of special emulsions for this purpose. This area of research also includes the utilization of materials already in use as floor finishes such as nitrocellulose and alkyds, but in a water dilutable form. In working with these systems, the use of a combination of water and solvents is sometimes necessary.

In conclusion, research in the area of floor finishes not only promises products with improved properties but possible products with new ease of application. Successful research in this area would also appear to have a bonus since these products should also be useful in the furniture finishing field.

What's New in Furniture Finishes

Lacquers: Lacquers still enjoy the largest part of the furniture finishing market. Some authorities place the figure for lacquers at 80 per cent of all the furniture finishes. However, synthetics are making inroads into this market, particularly in specialty finishes where extreme durability, alcohol resistance, or chemical resistance is desired. The use of synthetics will probably increase as ways are found to fit them into production more easily.

Lacquers of the nitrocellulose type or the newer nitrocellulose-acrylic types continue to enjoy their favorable posi-

tion because they combine beauty with versatility and high production speeds. There is little loss in production speed when processing a number of different lacquers simultaneously. With synthetics, however, continuous production needs to be carried on with one type of coating for maximum economy. Consequently, production disadvantages usually offset the advantage of greater durability to be obtained from synthetics.

CONTACT-ANGLE METHOD of determining wetability of organic finishes.

Synthetics: Among the synthetic furniture finishes coming into greater use are the amino-alkyd types. Fast curing coatings of this type are supplied as two-component systems, while some of the slower curing ones are single-package finishes that must be used fairly quickly because of their short storage life. These finishes combine alkyd with urea or melamine resins and an acid-curing catalyst. They may be cured to handle after one night's drying or after about 1 hour of force drying at 140° F.

These catalyzed finishes have excellent hot-cold check resistance. In addition, they are tough and durable. They have been difficult to patch and repair, but improvements are being made in this respect.

Polyesters: Polyesters have had only limited acceptance as furniture finishes thus far. This type of finish has the advantage of containing a reactive diluent that becomes part of the film. Thus, no solvent removal is necessary, and the films can be applied very heavily in single-coat application.

Some table tops and flat panels are cut from large sheets that are precoated with a polyester finish. These finishes must be protected from the air during curing because air inhibits the cure. Consequently, sheets of plastic may be laid over the polyester on flat work to shield it from air. This, of course, is not practical for most furniture. However, a recent development in polyester finishes has been the introduction of wax, which floats to the surface of the finish to prevent contact with air.

The addition of catalysts to the polyester finish is usually somewhat tricky. Therefore, polyester finishes are supplied as two parts, with the catalyst in one and the accelerator in the other. The two parts may be mixed shortly before application. Polyesters can also be made to cure so rapidly that they cannot be premixed and sprayed. In this case, the two components can be sprayed by a double-spray gun which either mixes the components within the gun immediately before application or mixes them within the spray.

Polyester finishes are noted for their toughness. However, this toughness presents sanding problems. Therefore, they are best suited for flat surfaces where belt sanding is practical.

Polyurethanes: These are one of the newest additions to the organic coatings family. They found wide usage in Germany during World War II, but only in the last few years did they come into appreciable use in this country. The producers of the polyurethanes are doing extensive research to develop specific coating formulations for all types of uses including wood. These coatings have excellent durability, water resistance, alcohol resistance, chemical resistance, gloss, and good depth. They have, however, tended to yellow on aging, but research in the use of ultraviolet light absorbers with polyurethanes has resulted in great improvements in color stability.

Polyurethanes are already being used in some specialty furniture finishes where outstanding solvent or chemical resistance is necessary, and research is continuing to broaden their usefulness.

Polyurethanes are available in either one- or two-component systems. They can be formulated for either air drying or baking. They can be formulated to dry by oxidation (isocyanate modified drying oils) or by chemical reaction of the isocyanate group, NCO, with other reactive groups in the resin mixture.

Epoxy Resins: Even though the epoxies are highly versatile, they have found limited application in furniture finishes thus far. Their excellent chemical resistance suggests possible uses in some specialty furniture finishes. In addition, it is possible to apply liquid epoxy resins without solvent or as very high-solids coating materials.

Among the disadvantages for the epoxy resins have been comparatively high price and a tendency for the coatings to yellow on aging. Again, improvements in color stability have been obtained by incorporation of the proper ultraviolet light absorbers. Research is also going on to find better curing catalysts and to utilize reactive solvents that become part of the cured film.

Color stability is probably more important in furniture than in almost any other wooden product that requires a finish. Considerable research has been done and is still going on to improve the color stability of furniture finishes and of the wood itself. An example of this type of research is the study made by the Hercules Powder Company on "Color Stability in the Finish of Light Furniture". Using a lacquer known to have good resistance to discoloration, they studied the effect of ultraviolet absorbers (incorporated into the lacquers) in stabilizing the color of woods. They found that some of the ultraviolet light absorbers had marked degrees of effectiveness on a relatively large number of woods. However, they were not effective with all woods.

Marine Finishes

For many years, the ultimate in clear wood finishes for marine use has been the spar varnishes. These varnishes made from phenolic resins and tung oil or tung linseed mixtures have excellent water resistance and, therefore, good durability on super structures of wooden craft. In recent years, attention has been given to the use of chemically catalyzed resin systems such as the amino catalyzed epoxy coatings and the polyurethanes. Ironically enough, continued research in the field of plastics and resins has not only led to better coatings for wood, but it has resulted in the replacement of wood for small pleasure craft by reinforced plastics. You are all aware, of course, of the tremendous advances made by the glass-fiber reinforced polyesters in heat construction. This obsolescence of existing materials and methods represents an inevitable result of research.

There is still an important demand for antifouling paints for wooden craft. These are highly specialized finishes that depend upon controlled leaching to prevent the build-up of barnacles and other fouling organisms on the ship bottom. The older type of antifouling paint depended upon a slow leaching of the coating vehicle or binder, such as a resin-fish oil varnish, to release the toxic pigments. A newer type of antifouling paint is based upon a durable vinyl vehicle which is highly enough loaded with the toxic pigment to make it available to prevent fouling. In this case, the pigment is leached to the surface to provide the toxic atmosphere.

The toxic pigments used to prevent fouling are copper, cuprous oxide, and mercuric oxide. Research is currently underway with other toxic pigments.

Summary and Conclusions

Modern finishes are doing a tremen- us job in all kinds of wood finish- g applications. When one considers at many years of satisfactory service e obtained from a thin coating one three or four thousandths of an ch thick, it is apparent that research s accomplished wonders. However, ere is still wide room for improve- ents in the direction of the perfect ating, which could be applied with- t solvents to the desired thickness a single coat, and impart all the operties wanted for the particular d use. Coating chemists continue to int their efforts toward this ever clusive goal. It is through the com- bined efforts of investigators working in the areas of (1) basic research, (2) raw materials development, (3) im- proved coatings formulations, and (4) improved end use application that there will be continual improvement of finishes for wood.

Floor Discussion, Session VII

Presiding Chairman, N. Clark Hatcher, Jr., Drexel Furniture Co., Drexel, N.C. Recorder: Donald G. Lubeck, Hammond Organ Co., Chicago.

Question: F. H. Thomas, Sherwin-Williams Co.; Have any clear fire-proof paints been developed?

Answer: No. Work is currently being conducted in many places on this project.

Question: G. Maurice Hill, Drexel Furniture Co.: Can the dry process of electrostatic coating of paper be used on wet applications?

Answer: No, because of insulation difficulties.

Question: E. Sigurd Johnson, North Carolina State College: In Germany they are presently applying finishing materials to wood by means of the electrostatic process. What should be the moisture content?

Answer: The moisture content of the wood must be 12 percent.

Question: Don Burnet, Crown-Zellerbach Corp.: How effective are the ultra-violet absorbers incorporated into wood finishes.

Answer: They offer some, but not complete protection.

Question: Johnson: Do absorbers lose their potency?

Answer: Some absorbers are permanent, some fade.

Question: Hill: Are the absorbers effective enough to keep customers from seeing the color differences?

Answer: The absorbers are good for awhile, but then the potency wears off and the discoloration begins to accelerate.

Question: Hill: What about rays other than U. V. causing discoloration?

Answer: It is our opinion that rays other than U.V. can give trouble.

Question: Alex Rose, Industrial Sales Research Co.: What is the present position of aluminum foil as a cigarette-proof method on furniture?

Answer: The use of aluminum foil has been given widespread interest but is given little use because of coating failures. One of the problems of using aluminum foil has been that of moisture affecting the bond. Work is being conducted in perforating the aluminum to allow for moisture transfer. in preventing the adverse effect of U. V. on light woods?

Wood's Future in the Packaging Industry[1]

R. S. KURTENACKER

Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

A summary of work completed or underway at the USFPL in efforts to maintain and improve successful and economic utilization of wood and wood products in the packaging industry.

BIN PALLETS are now being used in the harvesting of agricultural products. In the state of Washington, 25 percent of last year's apple crop was harvested in bins. Total investment in bins: approximately $3 million.

AT THE BEGINNING OF A NEW DECADE, everybody likes to look back over the past few years and at the same time gaze forward to the next 10 years. The packaging industry is no exception. During the past 15 to 20 years, authorities estimate that it has experienced a growth of over 300 percent.

The Author: Robert Kurtenacker holds a degree in mechanical engineering from the University of Wisconsin. Now with the USFPL's Packaging Research Division, he conducts research on behavior of container materials and fundamentals of container design.

Wood is one of the chief materials used in packaging. Moreover, the efficient and economical utilization of wood in the container and packaging field is of paramount importance to the overall lumber industry. Packaging provides an outlet for much lumber of low quality—lumber with certain defects not objectionable in containers but undesirable in other products of the sawmill. Such lumber, if not used for packaging, would probably be classified as scrap or waste. Without this outlet for the low-grade material, the economic situation of many wood processing mills would suffer and the cost of their other products would increase. The higher the costs of these products, the more vulnerable they will become to competitive materials.

Because of the importance of wood as a material product group in the packaging industry, let us look at the behavior of this group during the past decade or so. Statistics[3] indicate that, during the period 1939 to 1954, wood as a material product group increased 153 percent. While this was not the largest gain of the product groups,

[1] Presented at Session III, Packaging, FPRS 14th Annual Meeting in Montreal Canada, June 6, 1960.

[2] Maintained at Madison, Wis. in cooperation with the University of Wisconsin.

[3] Containers & Packaging Industry Report, Winter 1956-57. U. S. Department of Commerce, Business and Defense Services Administration.

DEMOUNTABLE consolidation container made of plywood and paper honeycomb sandwich material weighs 50 percent less than its steel counterpart.

EXPERIMENTAL BOX assembled with contact cement and rubbe re- quires less lumber and is lighter than conventional nailed wood ox of similar size and load-carrying capacity.

it is encouraging to note that the use of wood has increased.

Although complete figures for 1959 are not yet available for the entire wood products group, one segment of the group—nailed wood boxes and crates—indicates an increase of about 25 percent during the second quarter of last year. Early estimates place overall gains in the western States at better than 12 percent.

These are certainly encouraging figures on which to start the next decade, a decade in which all predictions indicate packaging will experience its greatest growth in history. What will happen to the wood products group in the packaging industry, only time will tell. Past history, however, has indicated that the greatest growth gains generally occur in the fields in which there is the greatest technological advance.

We believe that the last few years have provided some significant technological information that should be of value to the wood products group in the packaging industry. Some of this information is the result of the industry's initiative and desire, and some is the result of the research activities of the Laboratory.

Military Standard

The Laboratory was instrumental during the past decade, in establishing a military standard on the quality of wood members for containers and pallets. This standard establishes quality requirements for three classes of wood members in boxes, crates, and pallets, as well as for blocking and bracing within the container. Knots, cross grain, and wane are the primary defects considered in defining the quality of the three classes. Consideration is also given, however, to moisture content, decay, warp, checks, splits, and shake.

As one might expect, the purpose of this document is to standardize on the quality of wood for various packaging applications. For example, in highly stressed parts, such as the structural members of crates, class 1 material is required, while for nonstructural parts, such as sheathing and rubbing strips in crates and ends in boxes, class 3 or nonstructural material may be used. Thus, greater economy and better utilization seem feasible by establishing reasonable quality requirements for the wood based on the end use of the material in the container.

The three quality classes do not necessarily coincide with the commercial grades of lumber, but the requirements of the standard are such that conforming pieces may be economically obtained from commercially graded lumber. This standard, MIL-STD-731, has been coordinated with all the military agencies, the lumber associations, the National Wooden Box Association, National Wood Pallet Manufacturers Association, and Aero-Space Industrials Association.

Wood Pallets

During the last 10 years, a relatively new packaging item made spectacular gains in the industry. Born during World War II, the wood pallet has now come of age. Because of its po n- than apples, as well as for transp rt- great opportunities for using m re wood. New designs and methods are being tried continually.

One suggestion was that pallets might offer opportunities for enlarging the utilization of short-length lumber that otherwise might become waste. Since the top deck boards of a pallet appeared to be the most logical place to attempt such utilizatiton, we at the Forest Products Laboratory tested pallets with top deck boards that butted at their midlength. In either the two-way- or four-way-entry pallet, test results indicated that pallets with butt-jointed intermediate deck boards compared favorably with those made with unjointed intermediate deck boards. In pallet service, considerable damage occurs to boards on the edges of the top deck. It is therefore recommended that short-length material be considered only for the intermediate deck boards.

Bin Pallets

Perhaps one of the most spectacular developments in the harvesting f fresh fruits is the use of bin pall s in the apple industry. These bulk bi , generally made of wood, have a cap - ity of approximately 25 or more bu - els of fruit and are being used in t - States of Michigan and Washingt . In Washington, 25 percent of the c p was harvested last year in this m - ner, and the investment in the pal t bins represented nearly 3 mill n dollars.

These containers are finding oth r uses too. They have been propos d

nd tried for harvesting of crops other ıg, storing, processing, and shipping. n urgent need exists for developing ıme reliable and unbiased informaon on the design, durability, and onomics of these agricultural bins. o help find the answers, the Laboıtory has conducted field surveys of ns in actual use, and it has made boratory tests of different bin degns. The FPL has also prepared a ıblication[4] that discusses such phases "design consideration" and "good nstruction practices."

The Forest Products Laboratory beeves that, in order to maintain and ırther expand the pallet market for ood, it is essential to produce palets of good design and serviceability. Many inquiries are received along these lines, particularly in regard to the deck boards. Utilizing its past experience and information as well as newly developed information on pallets, a circular calculator has been developed for use in determining the load-carrying capacity of pallet deck boards. This interesting aspect of pallet design is discussed in detail in Report No. 2153, "Load-Carrying Capacity of Deck Boards for General Purpose Pallets," released in August 1959.

Boxes and Crates

No discussion of wood in the field of packaging would be complete without considering boxes and crates. Considerable technical information has been developed during the past few years, particularly with respect to the engineering aspects of crate design. Much of this information has been incorporated in the various crate specifications to provide for better wood utilization by reduction in the requirements for some of the members.

The information on nailed wood boxes has been reviewed and brought up to date in Report No. 2129. This publication discusses the design principles for the common styles of nailed wood boxes and includes recommendations concerning the selection of lumber, nailing and reinforcing techniques, a discussion on minimizing taste and odor contamination of food stuffs and the corrosion of metals in contact with wood.

Reusable Container

Other wood products, such as veneer and plywood, have also been involved in the Laboratory's packaging research aimed at improving or increasing their utilization. Plywood was ombined with resin-impregnated aper honeycomb to form strong, lightweight sandwich panels. These, in turn, were used to design a demountable reusable consolidation container for the U. S. Air Force. The resulting container measured approximately 8 feet in length by 6 feet in width and 7 feet in height, and was capable of carrying 9,000 pounds or 300 cubic feet of cargo. In addition to being collapsible, this container offered a 50 percent reduction in weight over its steel counterpart.

Paper-Overlaid Veneer

Container-grade paper-overlaid veneer represents a combination of wood, in veneer form, with paper to form a relatively lightweight and economical container material. This material is being used by the military as well as the aircraft industries, but engineering and technical information were lacking in the requirements of the box specification utilizing this type of panel material. In cooperation with the Quartermaster Food and Container Institute and Quartermaster Research and Engineering Command, laboratory rough-handling tests were conducted to develop engineering design information as well as factual data for better and more intelligent use of this packaging material. The behavior of these materials was examined during a year's outdoor exposure on a test fence. Toughness tests were made before and after exposure to ascertain the effects of weathering. This work showed that most of the domestic-type materials—intended for domestic use only—could not be expected to stand up too well under prolonged outdoor exposure. The durability of the overseas-type materials under exposure was encouraging, even though most of them showed some loss in toughness.

Continued Research

The Laboratory will, of course, continue research and investigation of wood and wood products in the packaging field. We are studying the behavior of open-crate frame members during rough handling by the use of high-speed motion pictures. Preliminary work indicates that the side vertical struts and diagonals deflect and vibrate when subjected to a drop test. At present, the problem involves a means of measuring this deflection. As more is learned about the behavior of these structural frame members, it should be possible to devise a more economical and efficient means of fastening the members together.

The wood box is also continuing as a subject of research. In the conventional wood box, the ends and cleats are generally thicker than the sides, tops, and bottoms. This is not so much for strength reasons as it is to provide adequate material to hold the fastenings, generally nails. It is widely known that the principal points of weakness in nailed wood boxes are the joints and fastenings. If something could be done to improve this, perhaps the thickness of the ends could be reduced without sacrificing box performance.

Following this line of action, the possibilities of adhesives, contact cements, mastics, and rubber are being explored. A combination of contact cement and rubber isolator has given encouraging results. Experimental boxes with ⅜-inch-thick sides, tops, bottoms, and ends were loaded with 471/2-pound, type 2 load. When these boxes were subjected to a drop-edgewise test, they performed as well as style 4 boxes of similar size with ⅝-inch thick ends and cleats and ⅜-inch-thick sides, tops, and bottoms assembled with sixpenny cement-coated sinker nails. Naturally, since this work is only in the exploratory stage, there are further refinements that need attention, but progress so far indicates that reductions of weight and material in nailed wood boxes are possible without sacrificing box performance.

This, then, is a brief summary of some of the work already done and underway at the Forest Products Laboratory in efforts to maintain and improve successful and economic utilization of wood and wood products in the packaging field. It is our belief that, by developing additional technological information about wood and its applications and uses in the packaging field, wood will remain competitive and retain a market in the packaging industry.

Floor Discussion, Session III

Program Chairman: Karl Bollerslev, Boise Cascade Corp.

Question: David Countryman, Douglas Fir Plywood Assn.: Mr. Kurtenacker, what rubber has been used as a cushion for wood packaging?

Answer: Our first work was with cyclized rubber electrician's tape and polyvinyl acetate adhesive. We are now using a reclaimed rubber contact adhesive and are experimenting with rubber sheeting.

Question: Ivan McDougald, McDougald Lbr. Co.: Has any work been done on glued-up plywood boxes?

Answer: Not yet, but we have done some work on glued-up plywood barrels.

Question: Sam Grober, Ecuador Lbr. Co.: Has balsa been used as an insulating material under a plywood skin for a thermal container?

Answer: No, not to my knowledge.

Question: Moss Christian, Chicago Mill & Lbr. Co.: Would there be an improved feature by gluing the cleats to plywood veneers for boxes?

Answer: No, shock loading would tend to cause early failure. When the cleat is glued, however, the rigidity of the panel is increased.

[4] Heebink, T. B., Bin Pallets for Agricultural Products. Forest Products Laboratory Report No. 2115, June 1958.

Fig. 1.—Accelerated weathering machines used to determine durability of hardboards and coatings; 120 specimens can be run simultaneously.

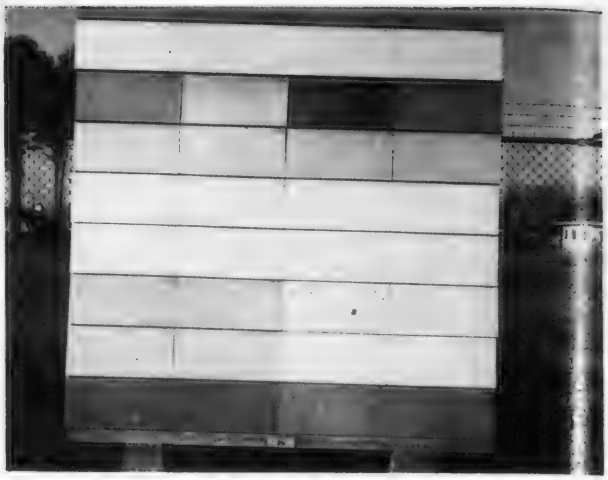


Fig. 3.—Complete 8- by 8-foot fence section, gives natural exposure with panels mounted on an aluminum strip. Panels were exposed raw, primed, and primed plus top coat of oil paint.

Exterior Durability of Hardboard

E. T. RUFFIN
Masonite Corporation, Laurel, Mississippi

Hardboard's durability is influenced by wood species, heat treatment, fiber additives, fiber refinement, tempering process, and severity of exposure. Here are results of accelerated weathering and fence exposures of various types of hardboard.

HARDBOARD IS PRODUCED from wood fiber by several processes. In the Masonite process, defibration is accomplished by a short-cycle steam cook at pressure up to 1000 psi, and the discharge of the softened chips through a restricted opening at high velocity. It is possible to vary the hydrolysis of the fiber simply by varying the steam pressure and/or residence time in the gun.

The effect of fiber-processing conditions is important; extensive tests show that weathering resistance is directly related to the degree of hydrolysis given the fiber, plus subsequent heat treatment in pressing the fiber into sheets, and secondary operations after the sheet is made.

Hardboard is produced in flat sheets up to 5 feet wide by 18 feet long, and in varying thicknesses from 1/12 inch to 1/2 inch. It has many of the characteristics of lumber plus the advantages of:

1. Being without grain, free of knots, and other imperfections;
2. Having about equal strength in both surface directions;
3. Having increased density and surface hardness;
4. No tendency to check, split, or splinter;
5. Having an equilibrium moisture content of about half that of lumber at any given humidity condition;
6. Smooth, dense surfaces which are easier to finish;

Since its appearance on the market in 1926, the industry has grown steadily. Hardboard uses have also expanded rapidly, and it is now being used increasingly as an exterior panel material.

Evaluating the Durability of Hardboard

A. Accelerated Weathering—Weather-Ometer. This artificial weathering method of testing the durability of hardboard coated or uncoated, is at best a rough screening procedure. It is extremely difficult and unreliable to try to correlate results of accelerated exposure with exposure to natural weathering. It has been found, however, that the Weather-Ometer is a useful tool for indicating trends, and its real value is in the increased speed that weathering tests can be made. It has been our practice to test fully all candidate materials in the Weather-Ometer, eliminate those whose performance is definitely poor, and prove those candidates that show promise by fence exposures to natural weathering (Fig. 1).

The Weather-Ometer cycle used in this study was as follows: 18 hours of exposure to light source provided by a single-arc, twin-carbon electrode; Samples are slowly rotated around the light source, and pass under a water-spray station once every 20 minutes; This cycle gives a 17-minute drying and a 3-minute wetting period for every 20-minute revolution; 3 hours of exposure to heavy water spray without light; and 3 hours of rest.

The light source has a total radiation and spectral distribution that approximates sunlight on a June day at noon. Special electrodes produce a continuous spectrum from 279 mu through 20,000 mu. Sample size is 2.7 by 12 inches. Panels are mounted vertically on a movable, open, drum-type carriage. Surface temperature during

The Author: Edward T. Ruffin is Assistant Research Manager of Masonite Corporation. He has been engaged in research on hardboard for almost 25 years.

[1] Presented at Session XV, Wood Composition Board, FPRS 14th Annual Meeting, June 9, 1960, Montreal, Canada.

[2] Author acknowledges assistance of T. H. Walton, H. R. Hunt, W. N. Meek, C. A. Blackledge, and R. F. Sutton of Masonite Research Department.

e 18-hour exposure reaches a maxi-
um of about 160° F. Distilled water
used for spraying to minimize iron
aining. The backs and thickness
dges of the specimen are not pro-
cted when testing boards for sta-
lity. Where coating quality only un-
r investigation, the backs and edges
the hardboard substrate are pro-
ted by a sealer.

Experience has indicated that par-
ularly weak coatings, or unstable
rdboard panels, can be identified
ithin the first 10 Weather-Ometer
cles. Good quality coatings and stable
Hardboard may weather as many as 50
cles without significant change.

Figure 2 shows the location of points of caliper measurement on a Weather-Ometer sample. Each sample is measured for the amount of board swell in mils, and in percentages, by

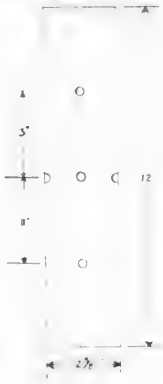


Fig. 2.—Locations of measuring points on Weather-ometer test specimen.

averaging the swell of the three center reference points. Edge swell is measured at two points as shown and recorded. Moisture gain in percent is calculated by:

$$\frac{\text{weight gain during weathering} \times 100}{\text{original weight}}$$

Board surfaces are carefully inspected at regular intervals during weathering, and the degree of surface fiber swell is noted. This condition is usually partially related to the efficiency of the fiber-refinement operation.

B. Fence Exposure: Figures 3 and 4 illustrate the type of fences used in this study. They are o uniform size, 8 feet by 8 feet, mounted 12 to 14 inches off the ground on concrete footings. Duplicate samples, approximately 12 inches by 24 inches, are exposed on (A) wet fences, and (B) natural fences. The former are equipped with spray heads that apply a fine mist of water at the top of the fence, which subsequently wets all the samples. This spray was regularly applied between :00 am and 12:00 noon each day.

Fig. 4.—General view of Masonite Corporation's natural fence exposures. Fences face due South, are 8 by 8 feet in size, and in a vertical position. More than 2000 specimens, representing various types of hardboard and many coating systems, are under investigation at Laurel, Miss.

The purpose of the wet fences was to accelerate natural exposure (Fig. 5).

In this study only lap siding types of hardboard siding were evaluated. Two types of mounting were used for the specimens on the fences. For convenience in mounting, many panels were attached with a specially formed aluminum strip attached to the wall. The edge of the test panel is grooved, and the grooved edge fits into this strip. The top edge of each tier of the siding is supported by the aluminum strip directly above, so that panels are firmly held in place at top and bottom, but they are not restrained in the lengthwise direction. Note that the aluminum strip is formed to provide about a ½-inch shadowline and a solid closure at the bottom, with weep holes every 8 inches to allow the escape of trapped water.

In other cases the siding is nailed to the studs on 16-inch centers. These panels are not grooved on the bottom edge, but they are slightly rounded on edge to allow more uniform paint application. Panels are lapped about 1½ inches to provide a shadowline effect. This siding is applied in thicknesses from ¼ inch to ½ inch.

All of the natural fences were covered over the studs with ¾-inch insulation sheathing, and they had a hardboard backing for the back side. The wet fences were not insulated, but they were protected on the back side with hardboard.

All fences were vertical and faced due South. Exposures have been made facing North, East, and West. Southern exposure is much more severe than exposures to the other directions. Western exposure is next most severe, followed in order by Eastern exposure and Northern exposure. The latter is comparatively mild on a vertical fence, since the sun's rays are never directly on specimens.

Wet-fence testing was discontinued after about 2 years because little additional knowledge was gained from this exposure method. Actually, the results were similar to those received in Weather-Ometer exposure, but they required much longer time to show up. These results are summarized:

1. Particularly weak coatings and hardboards with poor weathering stability were identified more quickly than the same exposures on natural fences. Results were somewhat erratic, however, and they were difficult to correlate with natural exposures.
2. Greater erosion of coatings occurred, since chalking was removed as fast as it formed.
3. Mildew did not form on the panel surfaces which were subject to

Fig. 5.—This demonstrates water spray application on wet fence. Spray was maintained continuously for 4 hours per day to determine to what degree wet-fence testing would accelerate natural exposure.

Fig. 6.—Mounting test panels on aluminum strip. No insulation or support is used between studs;

Fig. 7.—Natural fences ready for specimens. ¾-inch sheathing was used on studs and back of fence was sealed with hardboard; Aluminum mounting strips applied over sheathing and nailed to studs.

water washing, but mold growth was pronounced in the joints and on the bottom edges of the specimens.

Figure 8 shows a form used for recording the data developed in Weather-Ometer and exposure tests.

Inspection and Recording Data

It is important that test specimens be inspected at regular intervals. The same observer should be used for all inspections, and fence exposures should be examined during periods of dry weather. As changes occur on the specimens and defects develop, photographs should be taken as a means of reporting the progress of film or board deterioration.

Selecting the Proper Type Hardboard

Hardboard is an excellent material for most exterior applications, but just as in using lumber, or plywood, it is important that the proper type be selected for the end use.

It is a common belief that any tempered hardboard is satisfactory for severe weathering use. The weatherability of general purpose hardboards currently produced by the various manufacturers varies widely. Consequently, it is important to the industry and the consumer that this condition be recognized and only regular siding quality boards be used.

The process of tempering as commonly practiced enhances many of the properties of the board, such as hardness, flexural strength, bond strength, stiffness, and water and alkali resistance. Tempering does not necessarily render the board satisfactory for prolonged natural exposure.

Table No. 1 shows weatherometer results on a number of commercial hardboards of various types (not necessarily siding quality). In the table, the various boards are compared with ¼-inch exterior grade plywood as a control. It will be noted that these commercial products vary considerably in their weathering properties.

Our work has indicated that the durability of hardboard is directly related to several factors:

1. Wood species;
2. Severity of hydrolysis or heat treatment on fiber;
3. Type and amount of binder, water repellent, and other additives incorporated in the fiber;
4. Degree and uniformity of fiber refinement, and sheet formation;
5. Degree of consolidation;
6. Severity of exposure.
7. If painted, the quality of paint applied, its film thickness, and the maintenance of the coating.

In this paper we are dealing chiefly with wood species, effect of hydrolysis and painting practices.

Effect of Wood Species and Severity of Hydrolysis

A number of experimental hardboards were prepared from three kinds of wood fiber.

1. A mixture of southern hardwood species.
2. A mixture of southern pines.
3. Douglas-fir.

These various fibers were given varying degrees of heat treatment by means of the Masonite gun system. The hardwoods received a medium to severe heat treatment; the pines received three degrees of hydrolysis, and Douglas-fir received only the severe treatment.

Table 2 shows the results of 10 Weather-Ometer test cycles.

The degree that a hardboard substrate may swell is of primary importance in weathering. Swelling applies stresses against the paint film, produces severe stresses against fasteners, and induces warp because of localized restraint. Swelling is caused

Table 1.—RESULTS OF ACCELERATED WEATHERING TESTS (15 CYCLES IN WEATHER-OMETER) ON VARIOUS TYPES OF HARDBOARDS.

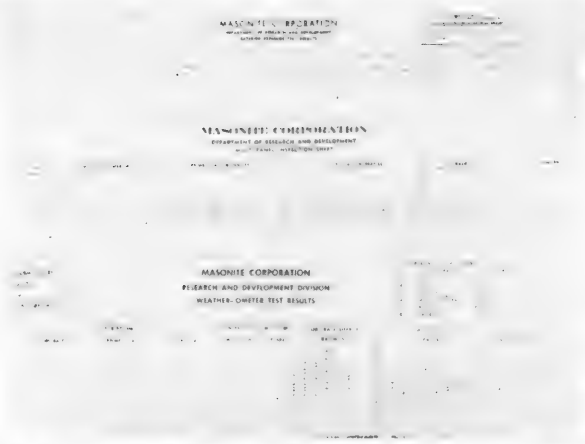
Code	Average Center Swell		Range of Edge Swell	Moisture Gain	Degree of Fiber Swell
	Mils	Percent	Mils	Percent	(Surface)
A1	23	9.1	21 to 23	28.9	Medium
A2	19	8.3	18 to 19	24.1	Medium
B1	65	26.6	88 to 102	35.0	Bad
B2	68	27.7	88 to 90	33.3	Bad
C1	64	24.0	77 to 78	38.0	Medium
C2	65	24.2	77 to 78	38.6	Medium
D1	23	10.1	37 to 39	13.9	Medium
D2	22	9.8	34 to 36	13.5	Medium
E1	50	20.4	59 to 64	33.5	Medium
E2	52	21.3	58 to 62	34.0	Medium
F1	51	23.7	51 to 59	59.0	Bad
F2	48	22.4	49 to 52	51.0	Bad
G1	54	22.8	62 to 65	40.2	Bad
G2	56	23.6	64 to 65	40.2	Bad
H1	29	11.7	50 to 54	11.2	Medium
H2	29	11.6	47 to 49	10.2	Medium
I1	65	25.0	68 to 69	45.5	Bad
I2	65	25.2	66 to 69	44.3	Bad
J1	26	10.5	18 to 23	77.0	Grain raised
J2	20	8.1	14 to 16	70.6	Same

All panels were approximately ¼ inch in thickness. Panels J1 and J2 were exterior grade Douglas-fir plywood.

Table 2.—ACCELERATED WEATHERING TESTS EXPERIMENTAL BOARDS.

Sample Identification	Degree of Hydrolysis of Fiber	10 Weather-Ometer Cycles: Average Center Swell		Range of Edge Swell	Moistu Gain
		Mils	Percent	Mils	Percen
Hardwood					
58-23-116-13	Medium	42	15.3	84.85	20.7
58-23-130-30	High	26	10.8	51-53	17.3
Pine					
58-23-36-49	Mild	30	9.5	73-79	14.4
58-23-110-1	Mild	41	13.7	73-74	17.1
58-23-110-10	Medium	26	8.2	53-56	11.0
58-23-133-2	Severe	16	5.9	45-46	14.7
58-23-142-43	Severe	18	7.6	43-45	11.6
Douglas Fir					
U58-19-30-2C	Severe	18	6.8	30-31	16.0
U58-19-30-3	Severe	15	6.2	24-27	9.0

All Panels Were Standard Hardboard in Approx. ¼" Thickness


MASONITE CORPORATION

RESEARCH AND DEVELOPMENT DIVISION

WEATHER-OMETER TEST RESULTS

Fig. 8.—Forms used for recording data: top and center, used for assemblying data on samples exposed on the fences; bottom, used for Weather-Ometer results.

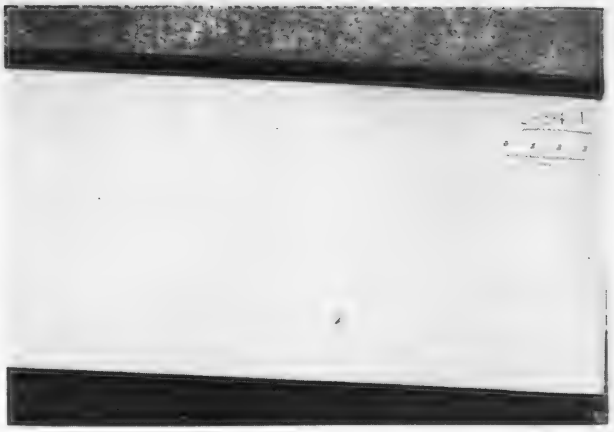


Fig. 9.—Hardboard siding from pine (severe hydrolysis); factory primed and top coated with conventional, long-oil, house paint; total film thickness = 3 mils. Length of exposure = 26 months due South, vertical an natural fence.

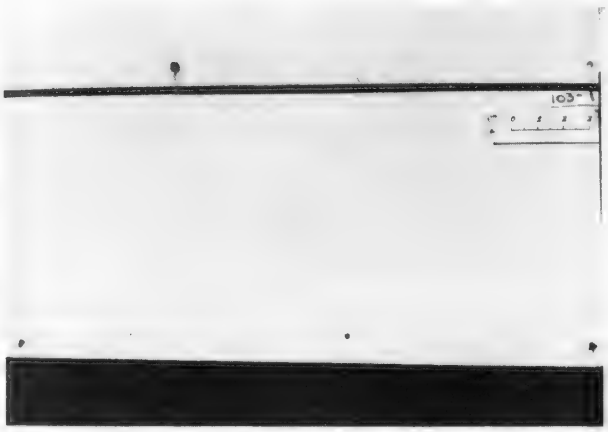


Fig. 10.—Hardboard lap siding from 70% pine—30% mixed hardwood (severe hydrolysis); Prime-coated with conventional oil primer; Top-coated with 2 coats of oil house paint; Total film thickness applied was 5 mils; Length of exposure = 63 months. Nail holes are visible because sample was removed for inspection.

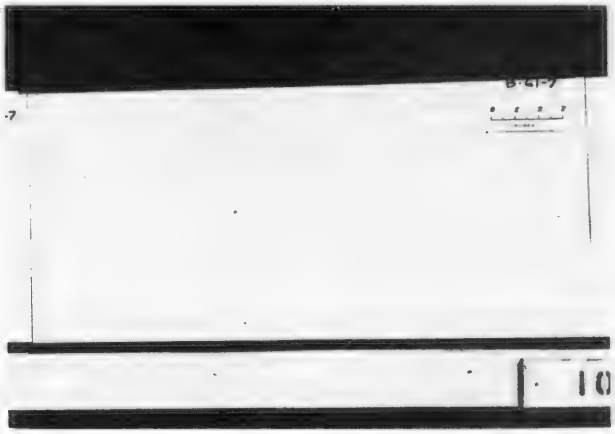


Fig. 11.—Hardboard siding panel from Douglas-fir (severe hydrolysis) was factory primed and top-coated with oil paint; Total film thickness was 4½ to 5 mils. Length of exposure = 26 months on natural fence.

Fig. 12.—Hardboard siding produced from pine (severe hydrolysis) and exposed, uncoated, for 26 months on natural fence.

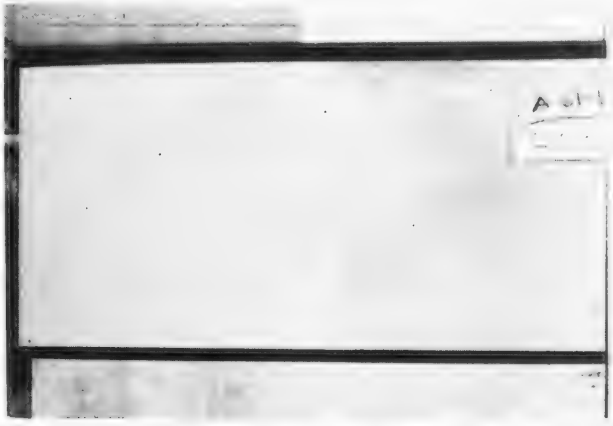


Fig. 13.—Hardboard siding from Douglas-fir (severe hydrolysis); Factory primed; Length of exposure = 26 months on natural fence. (One-half of panel wiped with damp rag to remove dirt.)

Fig. 14.—Pine wood siding primed and top coated with conventional, high-quality oil house paint. Total dry-film thickness 4–5 mils. Length of exposure = 28 months on natural fence.

Fig. 15.—Douglas-fir plywood ¼-inch thick panel (exterior grade), primed and top coated with conventional, high-quality oil paint. Total film thickness over 4 mils. Length of exposure = 28 months on natural fence.

Fig. 16.—Hardboard lap siding from pine (severe hydrolysis). Factory primed and top coated with 3 mils oil paint. Total film thickness = 4½—5 mils. Length of exposure = 27 months on natural fence.

by moisture penetration into the fiber. It is axiomatic that if water could be kept out of wood fiber, no swelling would occur, but since this has been impossible to do on extended exterior exposure, our efforts were directed towards reducing the magnitude of swelling in the presence of water. Extensive experimental work has been done on the use of sealers, water repellents, and coatings for shielding hardboard against moisture penetration. These treatments vary in their effectiveness, some of them successfully block liquid water, but none of them are sufficiently effective as a barrier against water vapor. Also, the use of this type of treatment requires application to both surfaces and both edges, a practice which is expensive and difficult in field application. Several types of plastic films are now available that weather well and are impermeable to moisture, but it has not been practical to apply these films as an envelope over Hardboard. It is practical, however, to produce a board with adequate resistance to swelling by proper hydrolysis or heat treatment, and to accomplish this without necessarily improving the board's resistance to water uptake.

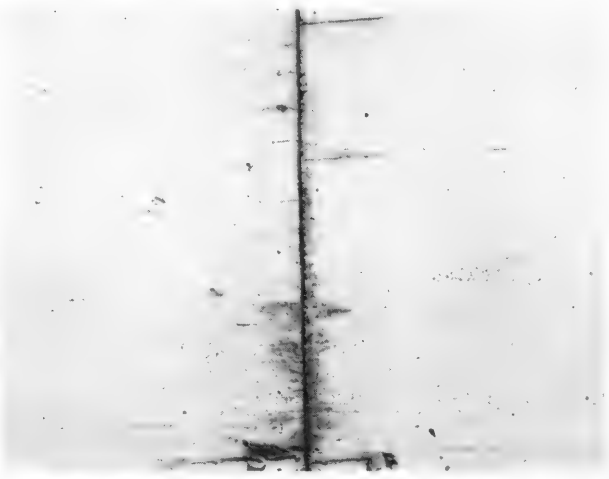


Fig. 17.—Douglas-fir plywood (exterior grade) primed and top coated with conventional oil paint. Total dry film thickness was over 4 mils. Length of exposure = 26 months on wet fence. Note the blisters formed under the film due to excessive water penetration.

Exterior Exposures

Table 3 summarizes the results of 2 years of exposure on natural fences of a series of hardboard panels produced from pine, and Douglas-fir. The pine had 3 levels of fiber hydrolysis (mild, medium, and severe), and the condition of the panels after 2 years weathering is directly comparable to the severity of the fiber hydrolysis initially. All panels were tempered and coated identically. Exposures on Douglas-fir have been made only on fiber that was severely hydrolyzed. At this level, it is as durable and perhaps more durable than pine.

Illustrations of hardboard with excellent weathering durability are shown in Figures 9, 10, and 11. The first is siding from severely hydrolyzed pine fiber. It was factory primed and top coated with one brush coat of oil paint. Total film thickness was about 3 mils. It has been exposed for 26 months and is in excellent condition, despite the fact that film thickness is less than that recommended. Figure 10 is an example of lap siding, from 70 percent pine—30 percent hardwood with severe hydrolysis. It was field primed and top coated with two coats of oil paint (linseed oil—titanium—lead—zinc). Total dry-film thickness applied was 5 mils. It has been exposed continuously for 63 months, and it does not yet require recoating. The nail holes on the bottom edge are visible because the panel was removed from the fence for examination. When it was replaced, the holes were not filled. Film integrity is still good. The panel shows no warp, and edge swelling is slight. Figure 11 shows a sample of hardboard manufactured from severely hydrolyzed Douglas-fir fiber. It was factory primed, and top coated with oil paint, giving a total dry film thickness of 4½–5 mils. It has been exposed for 26 months, and the only significant change is a moderate chalking of the paint.

The panel shown in Figure 12 is from severely hydrolyzed pine. It is

Table 3.—RESULTS OF NATURAL WEATHERING TESTS OF ¼ INCH THICK TEMPERED HARDBOARD PANELS EXPOSED FOR 2 YEARS ON VERTICAL FENCES FACING SOUTH

Sample Identification	Degree of Hydrolysis of Fiber	Condition After 2 Years Exposure		Significant Defects	
		Board	Coating	Substrate	Coating
Pine					
L-22-1, L-23-1	Mild	Fair	Good	Med. edge swell, slight groove swell, slight warping	Slight erosion
2-23	Medium	Good	Good	Slight edge swell, slight groove swell, slight warping	None
L-37-1, L-38-1	Severe	Good	Good	Slight edge swell, slight groove swell, slight warping	Slight erosion
Douglas Fir					
A-61-7, B-61-7	Severe	Good	Good	Slight edge swell, slight groove swell	None Note: All coatings showed heavy chalking.

All panels were mill-primed, then topcoated with two brush coats of conventional oil paint.

a panel without any coating or protection of any kind, and it has been exposed for 26 months on natural surface. The only changes evident are a moderate bleaching in color and slight raising of surface fibers. It is in excellent condition, capable of being painted without any surface preparation.

Figure 13 demonstrates a factory primed hardboard panel, manufactured from severely hydrolized Douglas-fir and exposed for 26 months. It is in excellent condition.

Painting Characteristics

Smooth, dense surfaces of hardboard influence many users to apply paint coats too thin for prolonged weathering. In many cases, they would not, or could not, finish lumber with such thin coats and provide the necessary protection.

Modern trends in finishing hardboard for exterior applications have emphasized the use of quick drying, low gloss, high-hiding paints. This type of paint is usually formulated with relatively short-oil length and high-pigment volume content. Experience has indicated these paints, as normally applied, are deficient in film thickness, flexibility, and adhesion. In many cases, they are more water sensitive than conventional house paint (linseed oil-titanium-leaded zinc). Extensive tests in accelerated weathering, as well as natural weathering, have shown that the high-quality, long-oil house paints provide durable and effective protection on hardboard.

Hardboard properly manufactured, correctly applied, and adequately protected with good quality paint will perform very satisfactorily in exterior exposures. It will require less frequent maintenance than most types of lumber. Parallel exposures of typical wood siding and hardboard, painted identically, nearly always shows greater durability and smoother surfaces for the hardboard (Figs. 14, 15, and 16).

Paint films gradually erode by chalking and the leaching action of water. The rate of erosion is affected by climatic conditions, direction of exposure to the sun, and other factors. Assuming paint quality is constant, the thicker the film—the greater the durability. It is also necessary that proper maintenance be observed. When the film has eroded to a point that it is too thin to adequately hide, it should be repainted. Repainting should be done while the original film is still intact. If it is delayed until the film cracks, peels, or loses adhesion, then it will be necessary to completely remove the old film. Our experience has shown that it is easier to repaint hardboard panels that have been neglected than it is to repaint most wood panels.

Blistering of paint film is a type of failure uncommon on hardboard, but it is a real problem on lumber. The problem has become so acute on the latter that specially formulated "Blister Resistant" paints are being widely marketed. Also, paints based on a vehicle that is relatively open to water vapor—so-called "breathing paints" are being recommended.

The advantage of hardboard in this case is attributed to its much greater resistance to moisture penetration, its higher density, and the fact that it is not subject to the wicking action characteristic of natural wood. Figure 17 shows blistering caused by excessive water penetration on plywood.

Our work on hardboard for exterior application is continuing. Hardboard with intrinsic weather-resistant qualities provides a serviceable economical base for extremely durable coatings and film overlays. Because of the long test period required to evaluate these systems—4 years of natural exposure is minimum for preliminary screening purposes—we are reluctant to discuss this important phase of hardboard application at this time. Perhaps our findings in this field will provide a companion report to this one at test completion.

UTILIZATION OF

Sawdust in Continuous Pulping

ROBERT LINKHART
Potlatch Forests, Inc., Lewiston, Idaho

TO MAKE A QUALITY PRODUCT from wood not being utilized in its sawmills, Potlatch Forests, Inc., a company well known in the lumber industry, entered the pulp and paper industry in 1950 at its Lewiston, Idaho mill. The sulfate "kraft" process was selected for this mill utilizing stationary type digesters. The slabs resulting from the production of lumber made unusually good pulp chips containing a high content of sapwood with long fibers and good strength characteristics. However, as the mill developed business in food board requiring quality printing, it was found that filler stock was needed to improve the sheet. An extensive research project, which included the study of sawdust, was inaugurated to accomplish this at the Lewiston mill. Tests revealed that sawdust from the large saws with wide kerf, normal to sawmill operation, had good fiber. Though many of these fibers were cut, this short fiber stock made good filler to blend with the pulp from regular chips. When it was discovered that sawdust tends to pack in a stationary digester, another method of cooking was sought. An experimental continuous digester was located in the eastern United States, and a shipment of mill sawdust was sent to this pilot plant operation for trial runs. A study of these runs showed that sawdust provided a satisfactory pulp when cooked in the *continuous digester*.

In October, 1953 a small, four-chamber continuous digester, with a single 15-inch screw feeder, was installed at Lewiston. Because of the success of this unit and plans for a large cylinder type paperboard machine, a continuous unit was designed and installed in 1955 for semi-kraft, high-yield cook using both chips and sawdust. The production from this unit was to be refined and used for filler stock in the inner plys of cylinder board.

In February, 1957 when the paper machine was changed to a Fourdrinier,

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The Author: Robert Linkhart is chief chemist for Potlatch Forests, Inc. A graduate of the University of Idaho, he is recognized for his developmental work on the use of chlorine dioxide for bleaching.

[1] Presented at Session IV, Chemical Utilization, FPRS 14th Annual Meeting, June 6, 1960, in Montreal, Canada.

The author describes a known pulping process—the continuous digester system—and tells how it worked out to the successful solution of the pulping problems of a mill with a peculiar fibrous raw material furnish.

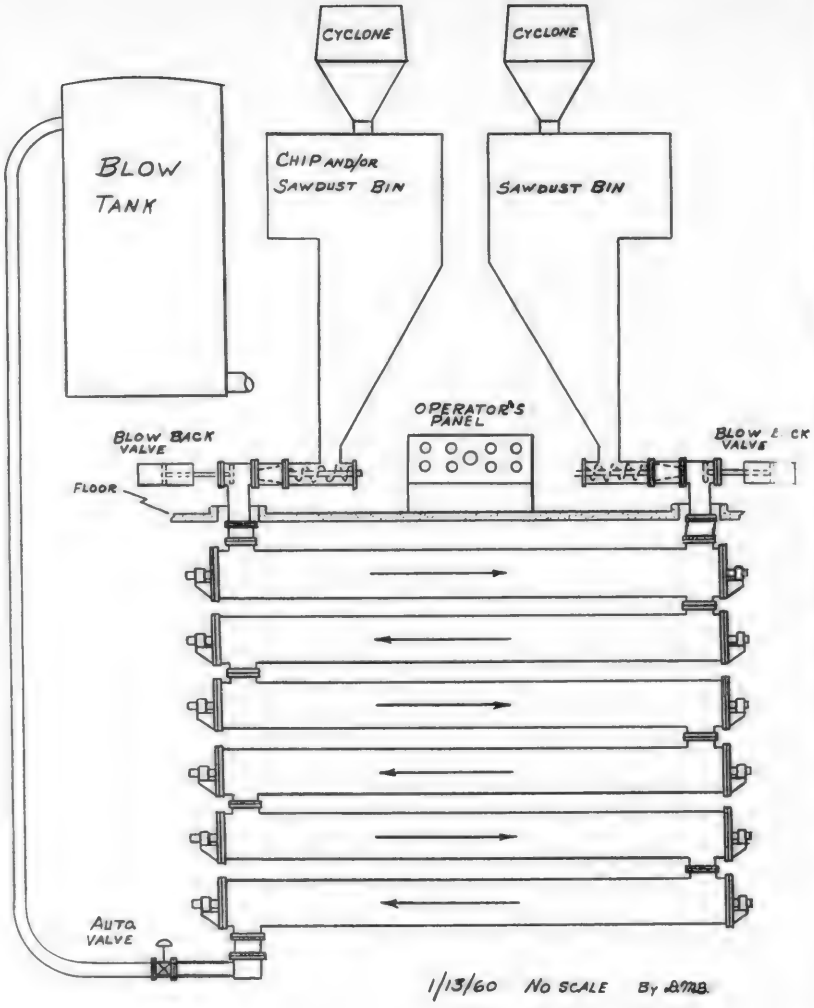
it became necessary to change to a full-kraft cook producing bleachable grade filler stock to be blended before bleaching with regular pulp made from chips. This change, along with the increased production of the mill, brought about a complete review of the program to utilize all available wood from the sawmill and still make an even better quality product.

Shavings from the planer mill had been recognized as having good usable pulp fibers. However, they were found to be dry and bulky to handle. Based on our experience in the lumber division with pressed-log product and with stoker briquettes, the shavings were partially compressed into small lumps somewhat similar to the briquettes. These were mixed with chips. Since this broke some fibers and caused other problems, a further study was made that resulted in their being mixed with sawdust for cooking, which proved to be the best way to make maximum use of them. As a result, all of the chip cooking is now done in the stationary digesters, and the continuous unit is used entirely for cooking sawdust, shavings, veneer waste, and fines screened from chips.

Sawdust from the sawmill is conveyed by belts to two large steel storage silos. Sawdust transported from two of our other mills by truck and rail car is also stored in the silos. Fines from the chip screens and shavings from the sawmill planer are added to the sawdust to make maximum use of all the available wood fiber in producing high-quality, easy-bleaching pulp.

From the silos, the sawdust is blown about 400 feet to steel hoppers over the screw feeders. Bin-level indicators are interlocked with the blowers and turntable at the silo to automatically stop the supply of sawdust when the hoppers are full and to start again when the sawdust level goes down.

The unit consists of two 15-inch screw feeders driven by individual 200 h.p. A.C. motors through an adjustable-speed dynamatic clutch and gear-reduction unit. Two feeders are used, because originally this unit was fed with both chips and sawdust.



SCHEMATIC DIAGRAM of the flow process of a continuous digester system.

Hot black liquor is introduced into the bottom of the hoppers above the screw feeders where it is used as a lubricating medium. These screws are manufactured of 316 stainless steel for maximum service life. When worn beyond tolerance, the screws are removed, overlaid, and re-ground in our machine shop.

The sawdust passes from the screw feeders through a restricted section where a plug is formed to keep the steam pressure of the unit from blowing back through the screw feeder. Beyond the plug section is the chemical inlet chamber, which is a large "T" where steam and liquor are induced into the sawdust. This mixture then drops to the first digester screw. The blow-back valve, a large, air-operated piston with a plate to fit the plug-section opening, is also located in the chemical-inlet chamber. This valve is used on startup to build a plug in the chamber, and, in case of trouble on the screw feeders, to keep the steam from blowing back.

Six screw-conveyor digester tubes, each 42 inches in diameter by 40 feet long, are located directly below the screw feeders. These are driven by individual 7.5 h.p. A.C. motors through an adjustable-speed dynamatic clutch and gear-induction unit.

The pulp is continuously discharged from the bottom chamber through a control valve and blowline to a small live-bottom blow tank. Non-condensable gases appear to be consistently mixed with steam and are relieved through the discharger. Typical temperatures obtained with 130 p.s.i.g. pressure are 345°F. in the second chamber, decreasing to 330°F. in the bottom (sixth) chamber. The temperature average is close to the 340°F. obtained in the stationary digester.

As noted above, the temperature ahead of the valve in the sixth chamber is 10°F. lower than in a stationary digester. This, along with the back pressure of the long 6-inch blow line,

ems to prevent damage to the pulp the blowing action.

Experience has shown that sawdust n be cooked to a permanganate lue two to three points higher than ips and still bleach properly after ending. This permits a higher ength and uses less white liquor. ie ratio of white liquor to wood for wdust is about the same as that for ips in the stationary digesters, even ough the cooking time is consider- ly shorter in the continuous digester bout 35 minutes). When cooking th chips and sawdust in the continu- as digester, the liquor requirement s 30 to 40 percent higher.

From a study of our sawdust cook- ing, we believe there is only a slight loss in strength by cooking in this continuous digester unit. This is based on comparison with cooks made in the laboratory experimental stationary digester. This loss could be accounted for by the shorter cooking time in the continuous digester. Due to the mechanical cutting of the fibers there is, of course, some loss in strength when compared to normal mill chips cooked in a stationary digester. When blending the pulps together in the mill, however, there is little effect on the strength compared to mill operation on straight chips. Lab work on blending shows that, with blends in the range used in the mill, the sawdust pulp does not have near the effect in reducing the strength of the blend as would be expected from the quantities and strengths of the two separate pulps. This proves that the sawdust pulp is very useful as a filler stock.

Originally, the digester was operated with only the amount of white liquor required for obtaining the desired permanganate number. Our experience shows that if too much liquid is used in relation to the wood, there is a tendency to wash sawdust past the chamber screws, permitting shives in the stock. If insufficient liquid is used, the mixture apparently becomes mealy and causes increased loading of the conveyors. Although we cannot see in the unit, it is our belief that the best consistency is one that makes the wood and liquor mushy so that it is easily conveyed yet is not wet enough to permit the liquor to separate or flow from the wood. To obtain this condition, we added a black-liquor feed, which is controlled by the operator's experience with the chamber amperage loading.

It is our understanding that at least one manufacturer has since recognized this same problem and has provided for the addition of excess liquid at the entry point. Under the first chamber, there is a screen grid through which excess liquor may be drained out of the stock and dropped to a tank for re-circulating. The white liquor is added on the basis of requirements for cooking, and sufficient liquor is recirculated to maintain stock wet enough to have some drainage in the first chamber.

The digester and related washing system was installed in the new paper mill building away from the pulp mill since it was originally intended to be used only for that machine. It was designed to be operated by two people, one on the digester and one on the press washing system. Through proper usage and location of instruments, knowledge gained by operating experience, and the mechanical improvements made, the two jobs have been combined, and there is now only one man per shift operating both the digester and the brown stock washing system.

Considerable work has been done at the Lewiston mill to improve the continuous digester operation. It is felt that with continuing efforts of equipment builders plus work done in the mills, continuous cooking will eventually replace the stationary digesters. Several new mills have recently started production with continuous digesters only. The use of continuous digesters makes it possible for the pulp industry to utilize all the wood not being used in sawmills for the production of a high-quality product.

Floor Discussion, Session IV

Chairman: F. G. Perry, Jr., Arthur D. Little, Inc.

Recorder: Mrs. Claire Canty, Arthur D. Little, Inc.

Question: J. J. Voci, Arthur D. Little, Inc.: What is the effect of differences between geometry of sawdust fibers and chips on cooking conditions?

Answer: We have had no problem adjusting pulping conditions so that we get satisfactory results with a wide range of particle sizes.

Question: D. B. Mutton, Industrial Cellulose Research, Ltd.: What species of wood do you pulp?

Answer: A wide variety, depending upon what the lumber and veneer mills are processing; for example, we pulp white pine, yellow pine, fir and cedar.

Question: What is the fiber size of the sawdust pulp relative to the fiber size of pulp prepared from conventional wood chips?

Answer: A mixture of sawdust and chips produces a fiber that's about one half the length of that obtained from an all-chip pulp. If shavings are used, the fiber length will of course be increased, and the pulp will have a higher strength.

Question: George E. Olson, The Dow Chemical Co.: Specifically what is meant by the reference to semi-kraft pulping?

Answer: This is the high-yield kraft process we use to prepare filler stock.

Question: Could you use sawdust with the cold soda process?

Answer: Yes.

Question: Burton Wilner, Wilner Wood Products Company: What are the relative economics of sawdust pulping?

Answer: The pulp is less expensive since the sawdust is avaible to the pulp mill for transportation or collection costs.

Question: Dr. A. S. Gregory, Weyerhaeuser Timber Co.: What is the capacity of this unit?

Answer: It was originally used as a 200-ton, high-yield unit. For bleached pulp, we operate at about 100 tons per day. We can go to 150 tons, but we prefer not to. The unit is a double-feeder system with six tube chambers."

Question: F. G. Perry, Jr., Arthur D. Little, Inc.: What is the limitation of the percent sawdust you can use?

Answer: This depends on the grade being produced. We have used up to 18 per cent with no ill effects in some instances. It is strictly dependent upon the way the product will behave on the paper machine.

Question: A. B. Anderson, University of California: What is the yield on a dry basis from a blend of sawdust and chips?

Answer: About 40 per cent but since pulps are blended in the storage chest it is difficult to measure yield accurately. We may lose a little yield with sawdust, but the use of press washers reduces the loss.

Question: George Olson: How does sawdust pulp compare to cold soda pulps?

Answer: The two are probably very competitive.

Question: F. G. Perry, Jr.: Is sawdust pulp comparable to hard wood pulp?

Answer: Yes, the two are very similar.

Observe National Forest Products Week

October 16–22, 1960

Wood Carbonization in Kilns

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U. S. Department of Agriculture

A search for economical designs for small charcoal kilns and for ways to improve production techniques showed that good-quality charcoal could be produced consistently in two of the three types of kilns investigated.

Fig. 1.—SHEET-METAL KILN of 1-cord capacity. During ignition the cover plate is removed as shown. After carbonization is well started, the 4-inch diameter chimneys are moved to the opposite side.

THE PRODUCTION OF CHARCOAL in kilns is an age-old business that has been revived during the past several years. Kiln production in the United States waned in the late 1800's with the development of the wood chemical industry which produced charcoal, chiefly as a byproduct, in distillation retorts or ovens.

The wood chemical industry reached a peak in the 1920's when there were over 100 plants (12),[2] then rapidly declined as synthetic chemicals replaced wood distillates. By 1947, the number of wood distillation plants had been reduced to 15, and in 1952 only 6 plants were recovering chemicals.

Prior to World War II, charcoal was used primarily for industrial purposes, and the demand was easily supplied by retorts and ovens; kiln production was relatively unimportant. During postwar years, however, the use of charcoal for restaurant, home, and outdoor cooking began to expand. A few of the remaining wood distillation plants abandoned chemical recovery and began producing only charcoal, and new kilns were built. But these could not satisfy the rapidly increasing demand, and by 1952 there was a serious shortage of charcoal (9).

It was not feasible to renovate old distillation plants or build new ones solely for charcoal production because of the depressed market for wood chemicals and the cost of building and maintaining such equipment. Consequently many new kilns of various types were constructed.

By 1956, there were 1,516 known charcoal production units in the United States with an annual output of 265,000 tons (13). More than two-thirds of these units were conventional-type kilns built of brick, masonry block, or steel, Small rectangular kilns of masonry block were, by far, the most numerous kind. Sixty-eight percent of all units had a capacity of less than 11 cords.

No national production statistics are available since 1956, but kiln construction has continued to expand and current annual production is estimated to be well in excess of 300,000 tons. Although wood chemical plants continue to produce a major part of total charcoal output, small kilns are becoming increasingly important in the industry (2).

Kiln Research Program

In 1955, in response to requests for information on the production of charcoal in kilns, the U.S. Forest Service initiated a program of research. A portion of this research was carried out by the Lake States Forest Experiment Station with the assistance of the Forest Products Laboratory (6). The principal objectives of this part of the overall program were to develop economical designs for small kilns and obtain information on the kiln process.

This report describes some of the results of studies conducted at experimental kilns near Three Lakes, Wis.

The Author: Paul H. Lane, a Purdue graduate, was formerly a Research Center Leader at Wausau, Wis. He recently transfered to the Pacific Northwest Forest and Range Experiment in Portland, Oregon.

[1] Presented at Session IV, Chemical Utilization, FPRS 14th Annual Meeting, June 6, 1960 in Montreal, Canada.

[2] Numbers in parentheses refer to the Literature Cited at the end of this paper.

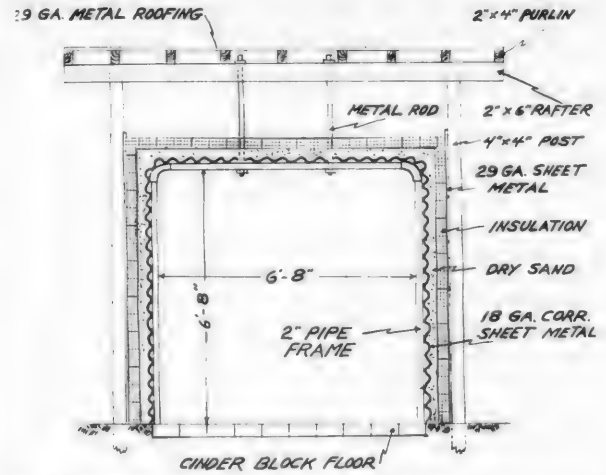

Fig. 2.—SCHEMATIC CROSS SECTION of a 3½-cord experimental sheet metal kiln.

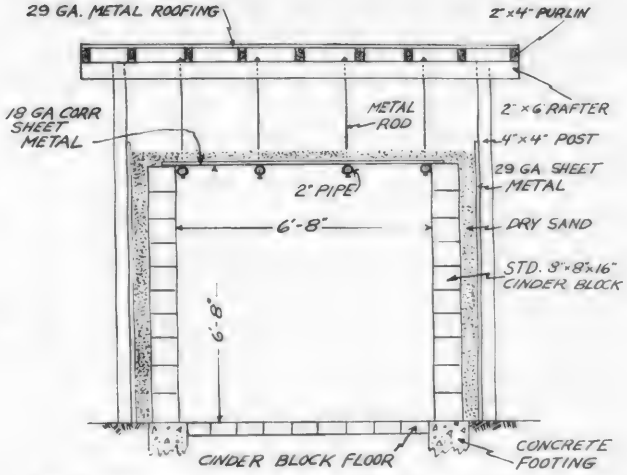

Fig. 3.—SCHEMATIC CROSS SECTION of a 3½-cord experimental cinder-block kiln.

Kiln Design and Performance

Three small, rectangular, experimental kilns were built to test certain design features and several types of structural materials for lining the kiln chamber. Emphasis was given to developing low-cost kilns that could be easily built from commonly available materials.

The three kilns were classified according to the structural lining of the kiln chamber: 1) sheet metal, 2) cinder-concrete block, and 3) refractory. A brief description of each unit and its performance to date follows.

Sheet Metal Kiln: Most commercial kilns of metal are small, modified steel drums, uninsulated, and of welded construction (1, 8, 11), as illustrated in Figure 1. Their chief advantage is portability. Some of their disadvantages have been described by Olson (8) and others. They include: 1) serious deformation of the structure from repeated heating and cooling, 2) excessive heat loss during coaling, and 3) high welding costs.

A metal kiln was built in an attempt to eliminate these problems (7). The principal features of this experimental unit are shown in Fig. 2. The composite walls provide both insulation to conserve heat and a column of sand to exclude air during cooling. The corrugated steel sheets lining the kiln chamber are overlapped and bolted to a pipe frame to eliminate welding. Expansion joints are provided at bolted connections.

To date, 16 burns have been made in this metal kiln, and overall performance of the structure has been very good. Kiln temperatures, frequently approaching 1,200° F. at the ceiling, have caused no apparent deterioration or serious deformation of the structure. The sand has functioned well in excluding air, and preliminary indications are that radiation losses are comparable with composite-wall, masonry block construction.

Cinder-Concrete Block Kiln: About 1945, the Connecticut Agricultural Experiment Station pioneered in the use of cinder-concrete blocks as a structural material for kilns (3). Subsequently, many kilns have been built of cinder blocks, most of them single-wall structures, patterned after the original Connecticut kiln. Well-made cinder blocks have generally performed well as a structural material when operating temperatures have not exceeded about 1,000° F. However, single-wall kilns of masonry block inevitably develop cracks at mortar joints from repeated expansion and contraction. For this reason, they are often difficult to maintain and make air-tight.

An experimental cinder-block kiln was built with composite walls in an attempt to solve the air leakage problem (5). Figure 3 illustrates the important features of this unit.

The 6-inch column of sand in the composite walls provided an air seal, but it was found to be unsatisfactory in conjunction with masonry-block construction. After four burns, "hair-line" cracks appeared in many of the mortar joints as expected. The cracks became progressively larger and more numerous with succeeding burns, however, because pressure from the column of sand restrained the walls from returning to their normal position upon cooling. After 19 burns, displacement of the masonry walls had occurred and the posts supporting the outer walls were noticeably bowed. Although the kiln is still usable after 29 burns, major repairs will be necessary before many additional burns are made.

Refractory Kiln: One kiln was built of refractory material with the objective of developing a unit capable of withstanding the highest temperatures likely to be encountered. As illustrated in Figure 4, the walls are standard 8-inch cinder block lined with a 3-inch thickness of castable refractory. The 6-inch-thick ceiling is a flat arch of light-weight, castable refractory and is suspended from angle irons.

During the initial burn, the kiln was subjected to temperatures well in excess of 2,000° F. for more than 5 hours. This is not intended to imply that 2,000° F. is required for curing. A somewhat lower initial temperature will cure effectively, and it is often advisable. In this instance, however, the objective was to determine the effect of extreme temperatures. Some small cracks developed in both the cinder blocks and the refractory from this initial curing burn because of normal shrinkage of the castable. Cracks in the refractory were effectively sealed with high-temperature mortar, and those in the cinder block with an asphalt-base mastic applied to the kiln exterior. No additional cracks or signs of deterioration have appeared during nine succeeding burns.

Initial cost of the refractory kiln was higher than that of the metal or cinder-block unit. Performance to date, however, indicates that this unit can stand more abuse, including the "run-away" temperatures that occur occasionally in many operations. It may be, in the long run, the most economical of the three types studied.

Cost of construction materials per cord capacity for the metal, cinder-

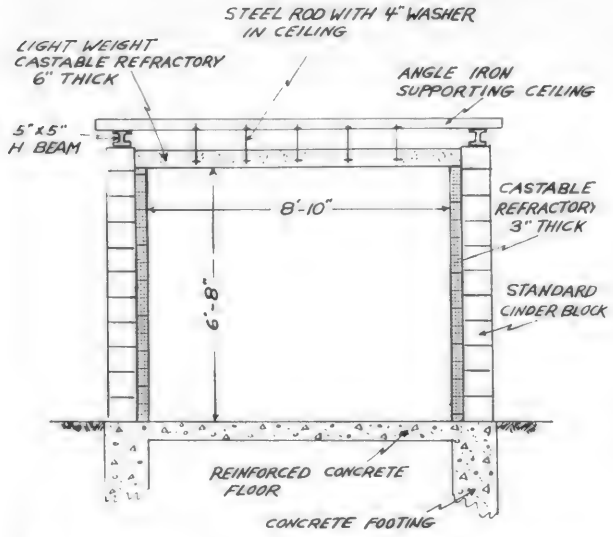

Fig. 4.—SCHEMATIC CROSS SECTION of a 4-cord experimental refractory charcoal kiln.

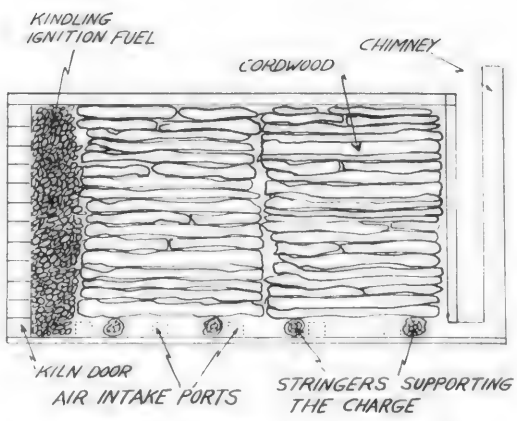

Fig. 5.—LONGITUDINAL SECTION of a "Connecticut" type kil showing typical method of loading a charge of cordwood.

block, and refractory kilns was about $130, $100, and $170, respectively.

More performance data are needed before the three designs can be properly evaluated.

Kiln Operation

Commercial Practices: Commercial kilns vary widely as to design and operating methods. However, the same general pattern of operation is used for most rectangular kilns of the "Connecticut" type. A charge of cordwood or mill residues is piled on stringers as shown in Figure 5. The charge is ignited by burning fuel placed at one end of the kiln. Ignition fuels commonly used are dry kindling wood, charcoal, or brands—partially carbonized pieces of wood, which are usually charred only on the outer surface. When an area of combustion, or "coaling zone", is established in the charge, air-intake ports along the side walls are opened and closed manually to move the coaling zone progressively through the load to the chimney at the opposite end of the kiln.

The kiln burning process is relatively crude when compared to retort or oven production. Process control depends largely on the skill and experience of the operator and requires close supervision.

Operating Procedures: Studies were made of the experimental kilns described for the purpose of developing information that might lead to mechanization and more scientific control of the kiln process. Five operating techniques were found to be particularly helpful in meeting these objectives:

1. Ignition of the charge with a gas- or an oil-fired torch.
2. Ignition and air entry at one central point in the charge with chimneys located at each of the four corners of the kiln.
3. Mechanical control of the air supply.
4. Process control by temperature measurement.
5. Predrying the kiln charge.

A brief description of these procedures and some of the test results follows:

1. **Torch Ignition:** The most common method of ignition is by fuel placed in the kiln as illustrated in Figure 5. Kiln operators frequently experience difficulty in obtaining rapid and satisfactory ignition by this procedure, particularly with a charge of green wood. If too little fuel is used, the combustion zone may be slow to develop or go out after the fuel is consumed. Ignition usually requires at least 1 or 2 hours. In addition, solid fuels occupy valuable kiln space and often require considerable labor to install.

Ignition with a small kerosene- or gas-fired torch of the "weed burning" type was found to be much more efficient than fuel placed in the kiln. These torches provide a positive, high-temperature flame that will readily ignite any charge in a few minutes. They are inexpensive and sacrifice no kiln space.

2. **Center Firing:** A series of burns was made to compare "center firing" using multiple chimneys with the c- mon commercial method of "end ing" previously described. In center-firing experiments, a chim- y was placed at each of the four corn- s of the kiln and all air needed for c- bustion was admitted through a sing-e port in the center of the kiln flo- r. The charge was ignited just above the air port and four, essentially inc- pendent, coaling zones moved simultaneously toward the chimneys. This procedure was found to be signifi- cantly better than end firing. Kiln temperatures were more uniform and single air entry made control easier. Average coaling time was reduced by 40 percent as shown below.

	End firing	Center firing
Number of burns*	3	3
Av. wood moisture content (percent)	29	35
Av. yield of charcoal (percent of oven-dried weight)	29	29
Av. fixed carbon content of charcoal (percent of oven-dried weight)	79	79
Av. coaling time (hours)	21	12

*Data from all six burns are comparable. Hard maple cordwood was used.

3. **Control of Air Supply:** Practically all kiln operators rely on natural draft to supply air for combustion. Consequently, the volume of air entering the kiln varies according to kiln temperatures and atmospheric conditions. Control is often difficult when outside winds are strong or variable. Similarly, natural draft may not be adequate for efficient ignition or coaling on calm, muggy days or when chimneys are cold.

Experiments were made with mechanically controlled draft in an attempt to improve coaling. An inexpensive, low-velocity fan, powered by a ¼-hp motor, was used to deliver

. the center of the kiln floor. The air passed through a 4-inch stovepipe laid under the floor and volume was controlled by a blastgate in the pipe. This simple equipment eliminated all of the serious disadvantages of using natural draft.

4. **Temperature Measurement:** Regulation of kiln temperatures is the key to efficient production and the control of charcoal quality. It is also good insurance against serious deterioration of the kiln structure. As previously indicated, most kiln operators rely on experience, gained by trial and error, in trying to attain process control. Only a very few make any temperature measurements.

At best, kiln temperatures are quite variable and coaling zones frequently move erratically. Knowledge of the time-temperature relationship is the only reliable basis for the regulation of coaling (15).

An inexpensive method for measuring kiln temperatures has been described by Peter (10). A microammeter, costing approximately $25, is used to indicate temperatures from thermocouples located at strategic points in the kiln chamber. The meter can also be attached to a thermocouple probe for measuring temperatures at various points in one or more kilns.

5. **Predrying the Charge:** Before wood can be converted to charcoal, all contained water must be removed by the application of heat. Production time can be materially reduced by air-drying the material prior to charging the kiln. In a study comparing freshly-cut hard maple cordwood with similar material that had been air-seasoned, it was found that air-seasoning reduced carbonization time 40 percent (16). Predrying not only saves valuable time, but also reduces the total B.t.u. requirement for carbonization.

Charcoal Yield and Quality

A number of factors affecting the yield and quality of kiln-produced charcoal were investigated, including time-temperature relationships, moisture content of the charge, and coaling procedures. A portion of the results are presented in Table 1 and in Figure 6.

The data are from 12 burns made in the same manner, using torch ignition, center firing, and fan-controlled draft. Raw material was hard maple cordwood, 4 feet long, and ranging from about 3 to 10 inches in diameter. Six burns were made with air-seasoned wood and six with freshly-cut or "green" material. Each charge was weighed just prior to loading, and its oven-dry weight was calculated from 20 to 24 sample sections. Temperatures throughout the kiln were recorded hourly with a potentiometer and about 25 well-distributed thermocouples. All charcoal, including fines, was weighed, and about 12 representative samples from each charge were analyzed by the U.S. Forest Products Laboratory for content of volatiles, ash, and fixed carbon.

Discussion

Additional performance data are needed from the three experimental kilns before any valid appraisal can be made of their long-range serviceability. However, the initial results clearly show some characteristics of the three structures. It can be concluded that sheet metal is a satisfactory structural material in properly designed kilns, especially if independent supports are provided to maintain kiln shape at high temperatures when steel has little strength. Further evidence of metal's utility has been shown by its good service as a kiln ceiling in other experimental kilns (14) and in commercial units that have masonry block side walls.

Performance of the castable refractories was very good, even under extremely high temperatures. This type of material shows considerable promise for providing a very serviceable kiln at a reasonable cost.

Results with the cinder-block unit proved that composite-wall construction, using a 6-inch column of sand with masonry blocks, is not satisfactory. If cinder blocks are to be extensively used, more research is indicated. Designs are needed that will provide for block expansion and a better method of excluding air.

The studies of operating procedures indicate a number of opportunities for mechanizing kiln operations and improving process control. For example, through a simple electrical relay system, thermostats within the kiln could automatically regulate an air-intake fan and control temperature. It would then be possible to develop reliable coaling schedules for any type of raw material and achieve automatic or at least semi-automatic process control.

The charcoal yield and quality data presented, illustrate that high-quality domestic charcoal can be produced consistently in kilns by the operating procedures described. The temperature data are indicative of coaling conditions required for producing charcoal with an average carbon content of about 80 percent. Obviously, the information on cycle time is not directly

Table 1.—CHARCOAL YIELD AND KILN OPERATIONAL DATA FROM 12 SIMILAR BURNS.[1] DATA GROUPED BY MOISTURE CONTENT OF RAW MATERIAL

	Raw Material[3]				Charcoal			Brands		Cycle Time	
Burn No.[2]	Charge Volume (Cds.)	Total Green Weight (Lbs.)	Calc. O.D. Weight (Lbs.)	Av. Moisture Content (%)	Total Weight (Lbs.)	Conversion[4] (%)	Av. Fixed Carbon[5] (%)	Total Weight (Lbs.)	Conversion[4] (%)	Coaling (Hrs.)	Cooling[6] (Hrs.)
					AIR DRY						
10–I	2.9	8,115	6,513	25	1,850	28	78	255	3	10	38
11–I	2.9	8,114	6,369	27	2,051	32	80	130	2	9	38
12–I	2.9	8,851	6,893	28	2,000	29	80	54	1	11½	34
5–II	2.6	8,558	6,474	32	2,002	31	79	268	4	13	38
6–II	2.9	9,190	6,612	39	1,970	30	80	524	8	12½	38
7–II	2.6	9,302	6,901	35	1,877	27	79	516	7	12	42
Av.				31		30	79		4	11	38
					GREEN						
11–II	2.7	10,685	6,894	55	1,782	26	80	52	1	19½	60½
12–II	2.7	11,160	7,525	48	1,832	24	80	354	5	19¾	58¼
13–II	2.7	11,110	8,027	38	1,758	22	81	259	3	19	38½
18–II	2.8	12,908	7,958	62	2,110	27	80	72	1	22	46
19–II	2.8	12,922	7,947	63	2,052	26	81	12	(neg.)[7]	20	45
20–II	2.8	13,221	8,171	62	2,200	27	80	100	1	18½	39½
Av.				55		25	80		2	19¾	48

[1] All burns by center firing with four chimneys, controlled draft, and torch ignition.
[2] Burn identification number. Burns No. 10–I, 11–I, and 12–I made in sheet metal kiln; balance in cinder-block unit.
[3] Hard maple cordwood, 4′ long, 3″ to 10″ in diamter.
[4] Percent of the calculated oven-dry weight of the charge.
[5] Chemical analysis by the U. S. Forest Products Laboratory.
[6] Time required to cool to 200° F. by natural radiation.

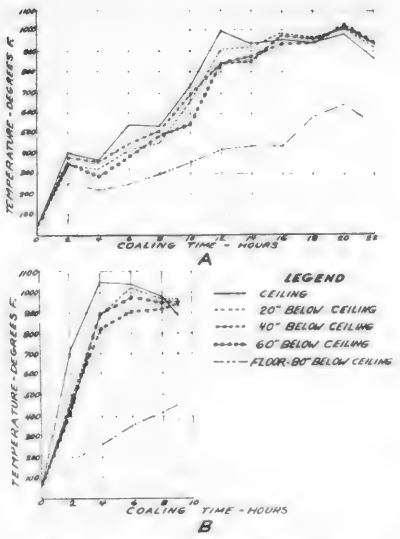

Fig. 6.—TIME-TEMPERATURE RELATIONSHIP for the carbonization of hard maple cordwood in a 3-cord experimental kiln, using center firing, four chimneys, and controlled draft; A—green wood, B—air-dry wood. Data from a typical burn for each level of moisture (burn No. 18-II and 11-I in TABLE 1).

applicable to kilns of significantly different size or to other operating conditions.

The time required for cooling by natural radiation (Table 1) was found to be relatively long, and more research is needed to eliminate this production "bottleneck". Some exploratory work with water sprays indicates that the method is promising (3, 4, 17).

Summary

A program of research was initiated by the Forest Service to develop economical designs for small charcoal kilns and obtain information on the kiln carbonization process.

Experimental kilns were built near Three Lakes, Wis., to study the performance of composite-wall construction and three types of structural materials for lining kiln chambers: (1) sheet metal, (2) cinder-concrete block, and (3) castable refractory. Initial performance data indicate that the corrugated sheet metal and castable refractories can, under the design conditions studied, provide an economical and satisfactory material for kiln chambers. Cinder-concrete blocks proved to be unsatisfactory when backed by a column of sand.

Studies of kiln-operating methods suggest five techniques for modifying some common commercial practices:

1. Ignition of the charge with a torch instead of relying on fuels placed in the kiln.
2. Center firing with multiple chimneys rather than progressive coaling from one end of the kiln to a single chimney at the opposite end.
3. Control air supply at one central point with a power-driven fan rather than relying upon natural draft through manually operated intake ports.
4. Control of carbonization by temperature measurement.
5. Predrying the raw material.

Results from experimental burns, using these procedures, demonstrated that good-quality, domestic charcoal can be consistently produced in kilns. For six similar burns of predried hard maple cordwood, the average charcoal conversion was 30 percent, brands 4 percent, fixed carbon content of the charcoal 79 percent. Coaling time was 11 hours, and cooling time 38 hours. The relatively long time required for cooling by natural radiation suggests the need for more research to develop better methods.

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Floor Discussion, Session IV

Chairman: F. C. Perry, Jr., Arthur D. Little, Inc.

Recorder: Mrs. Claire Canty, Arthur D. Little, Inc.

Question: Conrad Karras, Michael Wood Products, Inc.: What is the advantage of Connecticut type kilns over retorts?

Answer: Investment for even a small retort is much higher than for a kiln. For example, the investment for a kiln is only about $100–$200/cord of wood capac

Question: M. Yoshimura, Yale University, School of Forestry: Were the thermocouples in the horizontal or vertical plane?

Answer: They were in the horizontal plane about 1/3 of the way in.

Question: Did you get good heat-loss data?

Answer: We got some but not enough to tell the whole story.

Question: Were the temperatures uniform through the bed?

Answer: Fairly uniform. Slightly higher temperatures were obtained in the center, although there were short-term local hot spots.

Question: What is the 20 percent that is not reported as carbon?

Answer: Such things as water, light tars, etc.

Question: What temperature gave best grade of charcoal?

Answer: The standards for domestic charcoal have not really been fixed. It is generally agreed that a yield of about 80 percent and a kiln temperature of about 900°F. gave a satisfactory material.

Question: John M. Sayward, Vermont Bureau Industrial Research: What is the possibility of using gas analysis of stack gas (e.g., CO_2 content) as a means of controlling kiln operation?

Answer: We tried this in a very limited scale. Actually these kilns were not suitable for this type of research. We use the time-temperature relationship as a guide.

Question: Conrad Karras: What is the optimum number of kilns for a perpetual yield?

Answer: This depends on the raw material situation and the size of the kiln and the outlet for the charcoal product. As where from 5–20 kilns depending on individual situation. It is strictly a question of economics. One kiln operator I know has 5 units (85 cord capacity) and it takes him about a month to complete the cycle. He empties about one kiln a week.

QUALITY CONTROL BY TOLUENE EXTRACTION FOR THE

Procurement of Creosoted Marine Piling

MONIE S. HUDSON
Consulting Chemist, Spartanburg, S. C.

ALMOST 2,700 SOUTHERN YELLOW PINE PILING were used on the new Lake Charles, La., wharf, which is 1,000 feet long by 200 feet wide and accommodates vessels with 35-foot draft.

THERE HAVE BEEN TIMES IN THE past 15 or 20 years when it seemed that the creosoted marine pile was going the way of the steam train or the covered bridge, and that even the artists to whom the pile cluster with its resting gulls was a necessary prop for any sea-scape or harbor scene would have to substitute something less romantic like a steel girder or a concrete post.

By the end of World War II, the unquestioned monopoly of the field of marine structures by the creosoted wood pile had not only been challenged but was almost completely broken by inroads of the competition, steel and concrete. The time-honored records of the marine pile in the Ponchartrain Trestle and The Oakland Long Wharf were now overshadowed by the failures at Lake Maracaibo, Guantanamo Bay, and more recently Puerto Rico.

As a result of this, the wood-preservers, through their cooperating group The American Wood Preservers Association, began seriously a long overdue study of the question of what it takes to consistently produce a long-lived creosoted marine pile.

Out of their literature searches, and field and laboratory investigations, two requirements have emerged as being essential for a satisfactory marine wood pile. They were that it should be, (1) treated with the *proper* type of coal-tar derived preserative and (2) be treated with a *sufficient* amount of that preservative.

The preservatives committee of the AWPA has already recommended one change directed toward assuring that the best type of preservative is used for treatment of marine piles. This is contained in their manual of recommended practice standard P2-58, paragraph 9, which states: "Solutions for the treatment of marine structures shall be mixtures of creosote and coal tar in approximate proportions given." It is recognized that this method of characterizing the best preservative available is a more-or-less stop-gap provision, but the AWPA Preservatives Committee, as well as a special group at the U. S. Forest Products Laboratories sponsored by the American Wood Preservers Institute and directed by Dr. R. H. Baechler, are making good progress in more specifically pin-pointing the requirements that will define the best type of preservative for marine piling.

The first use of this direct method of determining whether the specified amount of preservative was retained in marine piling proved that quality control methods that protect the user will also help to preserve markets for wood.

Solubility Test

The TEG Furfural solubility test described by Stasse (AWPA Proceedings, 1955, page 112) shows promise of being a reliable method for more specifically characterizing coal-tar materials best suited for preservation of marine piles. Baechler in a recent paper discussing, "Extraction of Creosote From Marine Piles of Variable Age and Condition," has demonstrated that TEG Furfural Solubility affords a good criterion of the performance of a preservative in marine piles. In general, preservative solutions having a high degree of solubility in the TEG-Furfural mixture gave better protection than those showing lower solubility in the test.

The question of how much of the best type of preservative to use in treatment of piling for marine structures has in the past, been rather uncertain, but the best information now available indicates that this is in the range above 20 pounds per cubic foot. And this "in excess of 20 pounds per

The Author. Monie Hudson is inventor of the vapor drying process and the solvent recovery process, on which he holds numerous patents. He also holds patents on wood hydroylsis and dimensional stabilization of wood, and has published numerous papers on wood utilization.

[1] Presented at Session II, Wood Preservation, FPRS 14th Annual Meeting June 6, 1960 in Montreal, Canada.

cubic foot" figure means preservative content of the wood after treatment, not the older method of specifying retention in the wood based on tank gauge readings taken before and after treatment.

Since the beginning of the wood-preservation industry, consumers of treated wood have specified the operating procedures to be followed by the treating plant in order to obtain the product that they wanted. This led to an over-emphasis on how to treat the wood and tended toward too little emphasis on the quality of the finished product. The treater rightfully felt that if the consumer specified the exact manner of treatment then he should accept the product without too much quibbling about the final result.

A New Philosophy

In recent years, however, a new philosophy has arisen in the industry which de-emphasizes the question of how the treatments should be carried out, focusing attention where it should be, on the quality of the treated product. The most important result of the application of this new philosophy has been in the way that the amount of preservative retained by a charge is determined. Formerly, the consumer specified that the treater carefully measure the amount of preservative in his treating tank before using it to treat a charge of timber, and then remeasure it after the treatment was finished. The difference in the two measurements after the application of suitable corrections for differences in temperature, specific gravity, and moisture content at the time of the two readings was assumed to represent the amount of preservative that was retained by the charge. This method of determining retention was subject to a multitude of possibilities for error. In the complex piping system of a pressure-impregnating plant there are numerous valves, any of which could be leaking without detection, which would allow preservative to go to many other places than into the charge. Errors could be made by the treating operators in reading the tank levels, or errors made in the mathematics involved in correcting for temperature and other changes; and these errors could be made willfully by unscrupulous operators, if they so desired.

All of this led to searches for means of determining the amount of preservative in the treated timber itself. Weighing the wood before and after treatment has been used, but this is open to question because the treating process often causes large changes in moisture content of the wood which, unless corrected for by indirect means, gives erroneous values for retention. The direct method of determining creosote or other oil-type preservatives in treated wood is known as the "Toluene Extraction Method."

Toluene Extraction

With the development of the Toluene Extraction Method, which was adopted as a standard of the AWPA in 1959, the question of "How much preservative is in the wood"?, can be answered. Unlike the case of the tank gauge readings, it can be answered without adding mental qualifications like, "provided the 10-inch valve from the treating cylinder to the vacuum equipment was not leaking during impregnation of the piling," or, "provided the treating operator who took the first reading on the treating tank did not mistake 24 feet 10 inches for 23 feet 10 inches", thus making an error that would show the charge of piling had received 2,000 gallons more preservative than it actually did.

The first application of the Toluene Extraction Method as an inspection tool was made to determine whether the required amount of creosote-coal tar solution was contained in marine piles to be used for construction of a large wharf and transit shed.

The installation on which this method of inspection was applied was a 2 million dollar wharf built on Contraband Bayou, Lake Charles, La., for the Lake Charles Harbor and Terminal District on plans, specifications, and supervision of F. Shutts' Sons Engineering Company by Pitman Construction Company of New Orleans.

The new wharf is 1,000 feet long by 200 feet in width, and it accommodates vessels of 35-foot draft. The accompanying photograph shows a view of the completed dock and details of construction. This wharf represents an expansion of dock facilities that were built in the adjacent Calcasieu River in the late twenties and early thirties. Pilings for the earlier installations were treated with 80/20 creosote coal tar solution to a retention of pounds per cubic foot. These pil have given excellent service over period of 30 years. Analysis of borin taken from 20 piles in one of t wharves in 1959 showed a residu content of creosote-coal tar solution 9.6 pounds per cubic foot. Duri this 30-year period of service, the Ca casieu River exposure was not strict a true marine type but rather that of brackish estuary. In recent years, ho

TABLE I

RESULTS OF DETERMINATION OF RETENTION OF CREOSOTE-COAL TAR SOLUTION BY TOLUENE-EXTRACTION OF BORINGS FROM MARINE PILING.

	AT PLANT			AT JOB-SITE	
	LABORATORY A		LABORATORY B	LABORATORY A	
Charge Number	CCT SOLUTION lbs/cu. ft.	% H_2O	CCT SOLUTION lbs/cu. ft.	CCT SOLUTION lbs/cu. ft.	% H_2O
SUPPLIER NO. 1					
1	18.89	37.2	21.81	-----	----
5	20.19	41.1	23.03	18.28	44.3
6	20.79	37.3	21.31	20.90	44.1
9	24.17	38.4	24.51	22.24	40.1
12	23.91	41.3	25.56	22.59	45.7
13	20.72	39.0	21.57	17.88	40.4
17	21.92	41.3	21.55	19.47	39.3
18	19.32	46.0	20.20	21.01	39.6
19	19.99	32.9	20.98	21.66	31.2
32	24.21	42.4	22.77	19.11	44.2
35	24.70	41.9	24.57	23.16	43.6
36	25.36	47.7	25.27	22.13	43.9
37	23.34	44.3	24.49	24.21	42.4
Average	22.12	40.8	22.90	21.05	41.6
SUPPLIER NO. 2					
2	23.30	43.8	21.92	24.39	45.3
3	26.23	44.3	25.28	22.67	44.0
4	15.96	45.1	16.74	-----	----
7	22.02	42.2	23.06	-----	----
8	21.89	45.1	19.92	-----	----
10	21.92	37.6	23.04	23.37	37.0
11	21.93	37.6	21.05	22.19	39.4
14	20.70	44.0	20.03	24.60	40.0
16	26.01	43.5	24.05	25.00	39.2
20	21.00	46.9	19.46	-----	----
21	21.17	38.3	20.19	24.29	40.4
22	23.48	39.9	22.36	24.45	45.4
23	27.45	36.5	26.64	28.23	38.6
28	28.96	42.0	29.31	29.99	39.2
29	29.24	35.8	29.34	29.32	34.7
31	31.59	39.1	31.42	30.46	38.3
Average	23.87		23.36		
Average	24.85	40.1	24.47	25.95	40.0

ver, these conditions have changed adically because the channel connecting to the Gulf of Mexico has been ade wider and deeper. Stands of reently dead cypress trees all along the aterfront show evidence of this ange. Drift wood in the river riddled ith holes of teredo and heavily insted with pholads indicates that mane borer activity is high. Although test panels are maintained at Lake harles, it is probable that the level of rer activity there is between that reorted in the 12th progress report on arine borer activity by Clapp Laboraries, for Orange, Texas, and that reorted for Sabine, Texas.

Although personally convinced that would be the most satisfactory and conomical foundation for the new dock, the engineer was reluctant to pecify creosoted wood piling because of a previous experience in which he received some material of poor quality. When it was shown, however, that Toluene Extraction would be used as a control procedure to insure the quality of the product needed for the job, creosoted wood was allowed in the specification.

Requirements

The specification included a requirement that the retention in the piling to be used in the water be 22 pounds per cubic foot to take care of the increased marine borer activity and that the retention be determined by Toluene Extraction of borings taken from the treated wood. The specification also required that the contractor supplying the piling provide plant inspection by a nationally known inspection laboratory of the physical condition of the piles, the preservative impregnation process, penetration and retention by Toluene Extraction. As a further check on the quality of the material going into the new dock, the engineers reserved the right to inspect all materials received at the job-site and the entire job on completion.

A total of 2,633 southern yellow pine piling were used on the job. Piling used on the land side ranged in length from 35 to 50 feet. They were impregnated with an 80/20 creosote-coal tar solution to a required penetration of 4 inches or 90 percent of the sapwood and a retention of 16 pounds of solution per cubic foot. Piling used on the water side ranged in length from 60 to 80 feet. They were treated with a 70/30 creosote-coal tar solution to a required penetration of 1¼ inches or 90 percent of the sapwood and a solution retention of 22 pounds per cubic foot.

Comparative Tests

Since in the course of construction, piling was secured from a number of producers, this job offered an excellent opportunity to examine the wood-preserving industry's ability to produce really top-quality marine piling. A number of different laboratories were involved in the inspection, therefore, it was also possible to make cross-comparisons of the uniformity of preservative retention as determined by Toluene Extraction. Results obtained by different laboratories on samples taken from the same piles at the same time could be compared. Tests of samples taken from the same group of piles, but not necessarily the same individual sticks, when they arrived at the job-site could also be compared.

As is the case with any new procedure, some difficulty was experienced at first in obtaining the required retentions as shown by Toluene Extraction, and likewise in correlating results obtained by the different laboratories. The difficulties in obtaining the desired retentions were overcome by modifying the treating-plant procedures. Discrepancies in results obtained by the different laboratories were largely eliminated by following sampling procedures that would assure that comparative samples were taken from pieces from the same charge, if not the same individual piles. The apparatus and procedure for extracting the borings were as described in the report of the AWPA Preservatives Committees for 1958. (AWPA Proceedings 1958, page 147)

Table I shows the results of analyses of borings taken at two different plants and tested by two different laboratories. It also shows analyses of borings by one of the laboratories taken from piles from the same charges 1 to 2 weeks later at the job-site.

These figures show clearly that it is *consistently* possible to produce southern pine piling impregnated with creosote-coal tar solution to retentions in excess of 20 pounds per cubic foot as determined by the direct method of Toluene Extraction of borings. It will be seen, of course, that some of the charges inspected at the plants did not receive the required retention. These were re-treated. The fact that some of the charges failed to meet the retention requirement merely points up the need for having the retention requirement. As a whole, the charges requiring re-treatment because of failure to meet the retention requirement repre-

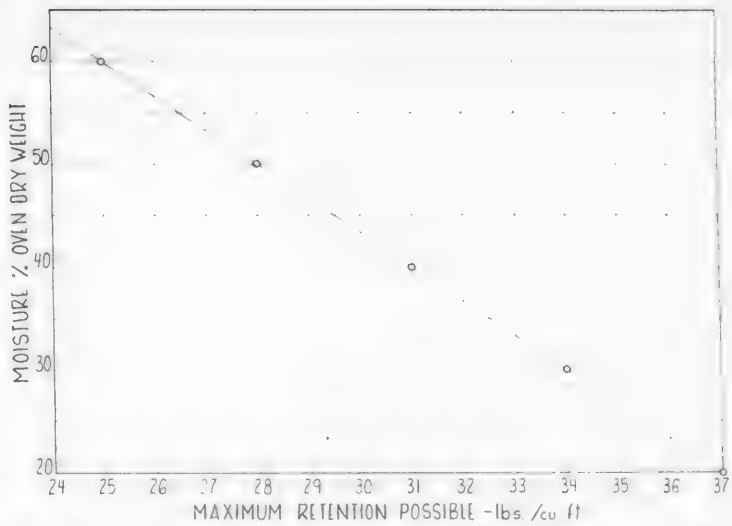

Fig. 1.—MAXIMUM RETENTION possible for creosote-coal tar solution in southern yellow pine having the average properties encountered in this study.
Oven-Dry wood wt. at green vol. = 29.0 lbs./cu. ft.; Wood substance 1.53 × 62.4 = 95.47 lbs./cu. ft.; Volume of wood substance $\frac{29.0}{95.47} = 0.304$; Creosote-coal tar solution specific gravity at 38°C = 1.093; Creosote at treating temperature 200°F. = 1.093 × .9619 = 1.051; Water at treating temperature 200°F. = .94482 × 62.4 = 58.96 lbs./cu. ft.; Creosote at treating temperature 200°F. = 1.031 × 58.96 = 61.96 lbs./cu. ft.;

% H_2O	lbs. H_2O Per. cu. ft.		cu. ft. H_2O		Cu. ft. H_2O + cu. ft. Wood Substance		Void Vol. cu. ft.		Maximum Solution lbs./cu. ft.
20		× 29		÷ 59		+ 0.304	1,000		× 61.97
30	5.8		0.098		.402		Minus .598		37.1
40	11.6		.197		.501		.499		30.9
50	14.5		.246		.550		.450		27.9
60	17.4		.295		.599		.401		24.8

sented no greater number of pieces than the number that had to be re-treated because of failure to meet the penetration requirements.

If the piles had been inspected individually for retention of preservative, as was the case of inspection for penetration, many more of them would have passed without re-treatment. This is because the retentions determined by Toluene Extraction are based on an average of usually 20 or more borings. A charge that averages over 19 pounds per cubic foot will probably be found to have one or two piles in it that average much less, say 10 to 15 pounds per cubic foot. If these non-conforming piles were eliminated from the average, it is likely that all of the rest would meet a 20 pound per cubic foot requirement without having to be re-treated. The fact that the Toluene Extraction procedure cannot be run on individual piles, without taking 10 or more borings from the single pile, represents a serious limitation of this method of inspection. As far as the treating plant operator is concerned, it causes him to have to re-treat piles that would not have to be re-treated if they were considered on an individual basis. On the other hand, it causes the user to take some piles that would fail to meet his requirements for retention. If he needs a retention of 20 pounds per cubic foot for the service in which the piles are to be used, for example, and he accepts the piles on the basis of an average retention for 20 or more pieces, it is likely that he will have in the 20 some piles that contain much less than 20 pounds per cubic foot, but which are off-set in the average by pieces containing more than 20 pounds per cubic foot. A method for rapid inspection of borings from individual pieces based on a colorimetric method has been developed by Hudson[2,3,4], but it has not been used for commercial inspection.

The averaged data in Table 1 show good agreement between samples from the same piles run by two different laboratories. The averages for samples taken later at the job-site also agree surprisingly well with those taken at the time of processing at the treating plant. The agreement of these averages supports similar observations by Baechler in his paper; "Determination of Retentions of Oil Preservatives in Heavily Treated Piling by the Extraction of Borings," (AWPA Proc. 1958, page 34).

Figure 1 has been constructed from physical data available on the piling supplied on this job and on the creosote-coal tar solution used in its impregnation. It is well known that the amount of preservative that can be injected into wood is controlled by the void volume or air space in the wood which is in turn controlled by the wood density and the moisture content. This figure shows that a moisture content of 40.8 percent at the time of treatment, which was the average for the 13 charges treated by supplier No. 1, the maximum amount of creosote-coal tar solution that could be injected would be about 31 pounds per cubic foot. The 22 pound per cubic foot average retention in these charges amounted to 70 percent of the maximum possible. In the case of supplier No. 2, the percentage arrived at in this manner is 80 percent. Note that charge No. 31, treated by supplier No. 2, had almost 100 percent of the void volume filled.

Figure 1 shows that it would be possible to obtain a retention of 2 pounds per cubic foot of creosote-coal tar solution in piles with a moisture content of 60 percent, and this would be with only 88 percent of the void volume filled.

This case demonstrates that producers of wood products can recapture markets that have been lost to competitive materials by studying their products to determine what improvements are needed, and to institute procedures of manufacture and methods of quality control that will assure the user that he will obtain the performance that he expects from his purcha-

[2] Hudson, M. S. Colorimetric determination of creosote in poles. For. Prod. Jour. Vol. V (11), pp. 34-344.

[3] ———. Determining creosote in standing poles. Telephony. Nov. 1955.

[4] Rawls, J. A. and M. S. Hudson. Pole line inspection and its increasing importance. Amer. Inst. Elect. Eng. Conference Paper No. 55-55, 1955.

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UMBER DRYING AND QUALITY CONTROL OF

Moisture Content in Kiln-Dried Lumber[1]

H. H. SMITH AND JOHN R. DITTMAN

Objectives were to find the accurate MC and the percentage of each type of wood per green-chain segregation, to determine drying time of commercially used schedules and find ways to reduce the time, and to determine the effect of solid or bulk storage on final MC.

Figure 1.—A, THREE TYPES of white fir wood; B, Two types of wood, such as sap and cork, or sap and sinker, often occur in one board.

IN THE SPRING OF 1959 THE PACIFIC Southwest Forest and Range Experiment Station began a cooperative study of lumber drying with the Winton Lumber Company at its Martell, California, plant. The study was aimed primarily at the drying of commercial white fir, which in this area includes both *Abies concolor* and *Abies magnifica*. These two species are very similar in properties and are not distinguished in the trade. Because the drying problems studied are common to other woods, white fir was not the only species used. Ponderosa pine was used in studying the effect of solid or bulk storage. Some of the results should therefore have wide application.

The Authors: Harvey H. Smith, a graduate of the University of Michigan and former staff member of the USFPL, is now a forest products technologist at the Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.; John R. Dittman holds a BS in forest management from Oregon State College and is superintendent of the Winton Lumber Co., Martell, Calif.

The study was prompted by the installation of an automatic electronic moisture meter that scans a large area of every board passing over the dry chain. The quality of the kiln drying at the Winton Lumber Company was good to excellent as judged by industry standards. However, the use of the automatic moisture meter showed a much greater range of final moisture content in kiln dried lumber than had been supposed. This more accurate measure of final moisture content raised the problem of how best to kiln-dry white fir and associated species in the minimum time while maintaining the maximum value by reducing drying degrade and improving the uniformity of final moisture content of the kiln dried lumber.

Th most serious problem in kiln-drying white fir to a uniform final moisture content is the segregation of the green lumber into homogeneous kiln charges. Other species present a similar drying problem. In the west, redwood and western redcedar are notable examples. In the south, sweetgum is probably the best example, but other species also produce wood with different drying characteristics within the same tree.

White fir has three distinct types of wood: cork, sap, and sinker. Cork-type is heartwood from high in the tree. It has a low moisture content. Sap-type is the outer, living portion of the stem, extending the full height of the tree. It has a high moisture content. Sinker-type is heartwood found low in the tree, usually in the first log. It also has a high moisture content.

There are two problems in segregating white fir lumber into drying sorts. First, identifying the three distinct types of wood. Second, applying rules or guidelines for properly placing individual pieces containing two or more types of wood.

Distinguishing the three types is relatively easy (fig. 1). The Western Pine Association has clearly described each type. The real difficulty comes in properly placing pieces containing two or more types.

Objectives

There are three main objectives in the parts of the study reported here: (1) Determine the nature of the present green-chain segregations as to moisture content and percent of each

[1] Presented at Session XVII, Wood Drying, FPRS 14th Annual Meeting, June 9, 1960 in Montreal, Canada.

type of wood in each segregation, (2) determine the drying time for each type of white fir when dried by kiln schedules now used commercially and known to be acceptable and study possible methods of reducing the drying time, and (3) determine the effect of solid or bulk storage of kiln dried lumber on the final moisture content.

Procedure

Green-Chain Segregation

To study the present green-chain segregations—cork, sap, and sinker—10 sample boards of each segregation were selected at random from regular production lumber that had been marked by the company grader. A 1-foot long section was cut from each end of each board. A 1-inch section was cut from a position 10 to 11 inches from the original board end. On this freshly cut end surface, the divisions between the three types of wood were marked. The three types of wood were then separated by bandsawing along these marked division lines (fig. 2). Each segment was marked for further identification, weighed, ovendried to constant weight, and reweighed. The moisture content of each segment and the full cross section was calculated. The ovendry weights of the separated segments were used to determine the percent of each type of wood in each commercial segregation.

To increase the size of the sample and to determine more accurately the industry practice of white fir segregation, two other mills were included in this phase of the study. Data from all three mills were combined for this report.

Drying Time

To study the drying time for each type of white fir by accepted commercial schedules and possible methods for reducing the drying time, seven kiln runs were made in a small experimental kiln, built by the U. S. Forest Products Laboratory, Madison, Wisconsin, that had been used in California for the experimental drying of western hardwoods. This completely equipped and instrumented kiln is located at the research laboratory of the California Cedar Products Company, Stockton, California, and is being operated in cooperation with that company.

Figure 2.—SAP SEGREGATION samples with varying amounts of cork-type wood separated for determining moisture content.

Each experimental kiln run consisted of 1⅞-inch x 12-inch x 8-foot dimension lumber, to make up a charge 4 feet wide, 4 to 5 feet high and 8 feet long. The volume per charge ranged from 432 to 608 board feet.

The first two runs were "sap" segregation, as marked on the green chain by the company grader, and can be classed as "commercial sorts." Each plank was predominantly sapwood, but could include narrow streaks of sinker-type wood or small to fairly large areas of cork-type wood.

The schedules used were similar to or slightly milder than commercial schedules for this type of stock. The progress of the drying was followed by using 16 kiln samples cut from representative material.

In all runs after the first two, the test material was selected to represent "pure" sorts. Each plank of any one type was virtually 100 percent that one type of wood. "Cork" planks were all cork, "sap" planks were all sap, etc. In these five runs, the drying rate of each type of wood was determined.

Kiln samples were again prepared, and the moisture content of each charge was followed during the drying cycle by periodic weighings. The samples and the 8-foot planks were removed from the kiln as soon after they had reached a moisture content of 20 percent as was practical (figs. 3, 4 and 5).

The head grader graded all test lumber at the green chain, again after kiln-drying, and finally after surfacing. Though only reasonable commercial schedules were used in this series of seven kiln runs and no serious drying degrade was expected, this grading procedure was used to measure the general quality of the drying. This measurement of degrade is at best only a rough check or indicator, and more accurately reflected in change of grade from green to rough-dry than from rough-dry to surfaced-dry.

Effect of Storage

Lumber that will be remanufactured (particularly if the lumber will be glued) requires drying to a lower and more uniform moisture content than dimension lumber. Five-quarter Shop and Better ponderosa pine was used for this part of the study. White fir and other species are expected to respond to storage in a similar manner.

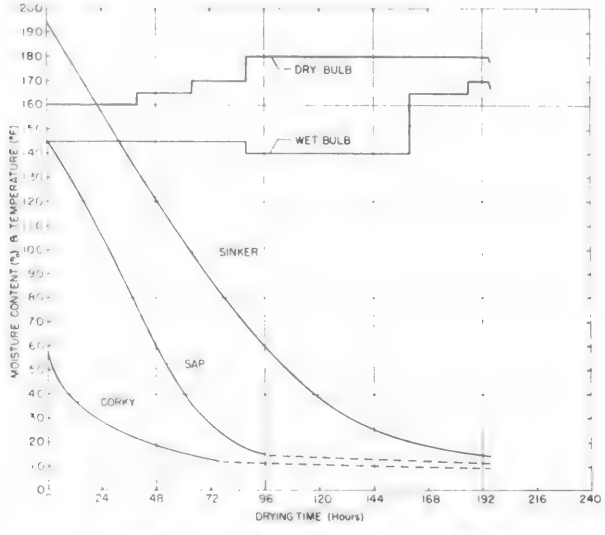

Figure 3.—KILN SCHEDULE and drying curves for three types of white fir.

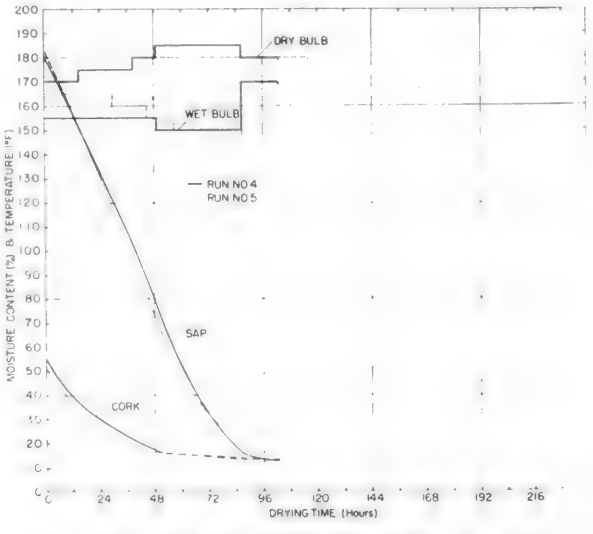

Figure 4.—TWO KILN SCHEDULES and drying curves for sap and cork types of white fir.

To the extent this is true, the results should have wide application.

The procedure for studying the effect on final moisture content of solid or bulk storage of kiln dried lumber was relatively simple with the equipment at hand. Only one electrode of the automatic moisture meter, capable of marking both too wet and too dry, was used in metering the study lumber. The meter is equipped with two electrodes each 4 inches x 14 inches in area, positioned to scan each board across the full width at a position approximately 3 feet and 10 feet from the end. Both electrodes normally activate the inking device that marks the boards where the moisture content is outside (either above or below) the preset limits. With both electrodes operating, there is no indication of which is activating the inking device. It is possible that boards with very great longitudinal variation in moisture content, as in a piece of white fir predominantly sinker-type wood at one end and cork-type wood at the other end, may be marked as both too wet and too dry at the same time. This is unusual, but pieces are often marked as too wet on one area and too dry in another area. Therefore, to insure metering and remetering in exactly the same place on each study board, only one electrode was used (fig. 6).

The meter was first calibrated by using sample boards having a uniform moisture content in the optimum range (8 to 10 percent) for measuring with an electrical moisture meter. A small portable moisture meter with 1-inch long insulated electrodes was used to determine the maximum moisture content of the sample boards. The automatic moisture meter was adjusted to accept lumber within an average maximum moisture content range of 8 through 12 percent. Boards above 12 percent were automatically marked red (too wet) and boards below 8 percent were automatically marked green (too dry). With only one electrode operating, the marks are inked on each board in those areas across the width that are above or below the preset moisture content limits.

Lumber that had been marked too wet was pulled from the dry chain to make up two bulk-piled carrier units. As the boards were pulled from the dry chain the length of the marks was measured and recorded.

Moisture readings with the small portable meter were made in the same areas of each board scanned by the automatic moisture meter. The moisture content of the lumber in the two piles ranged from 12.1 to 16 percent.

The two units were moved to a covered dry-storage shed.

After one week of storage, Unit No. 1 was returned to the dry chain, and each board was remetered in the same area as when first metered. The length of ink marks resulting from the second metering was also measured and recorded.

After two weeks, Unit No. 2 was returned from dry storage to the dry chain for remetering in similar manner.

Results

Green-Chain Segregation

In the commercial segregation of white fir, each of the three segregations—cork, sap, and sinker—contained some of all three types of wood (table 1). The cork segregation appears to be most accurate with over 80 percent being cork-type material. Only 59.5 percent of the sap segregation was sap-type wood, and 63.1 percent of the sinker segregation was sinker-type wood.

The range and average moisture content for each type of wood in each segregation is also revealing. The moisture content of cork-type wood in the cork segregation was lower than that of cork-type wood in either the sap or sinker segregation. It was highest in the sinker segregation. The moisture content of the sap-type wood was highest in the sap segregation and lowest in the cork segregation. The moisture content of the sinker-type wood was highest in the sinker segregation and lowest in the cork segregation.

The moisture content of each type of wood as determined in preparing kiln samples for the experimental drying showed even greater variation between the three sorts. This carefully selected material showed a moisture content of 50 to 60 percent for the cork (average 55.1 percent); 145 to 180 percent for sap (average 170.3 percent); and 170 to 195 percent for sinker (average 181.3 percent).

Drying Time

The most striking results of the experimental kiln-drying of the three sorts of white fir were (1) the uniformity of drying time within each of the three types of wood, regardless of the schedule used, and (2) the extreme difference in drying time between the three types (fig. 7).

Drying time of sapwood was twice that for cork; and for sinker wood, twice that for sap (table 2).

Degrade

Much of the lumber in these seven experimental kiln runs was dried to a lower final moisture content than is desirable for machining dimension lumber. The average final moisture content of all test material was 12.1

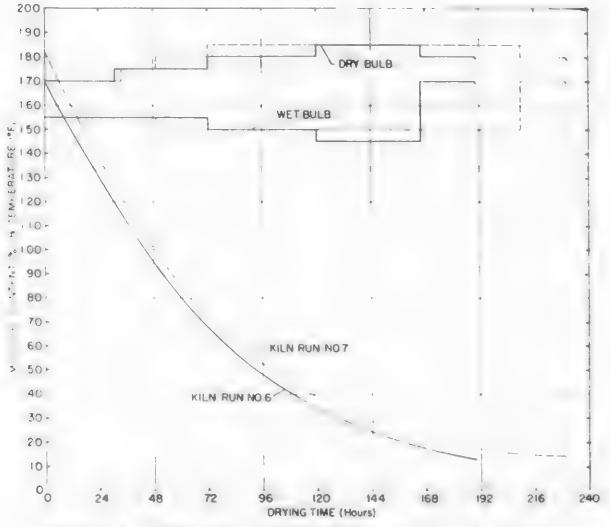

Figure 5.—TWO KILN SCHEDULES and drying curves for sinker type of white fir.

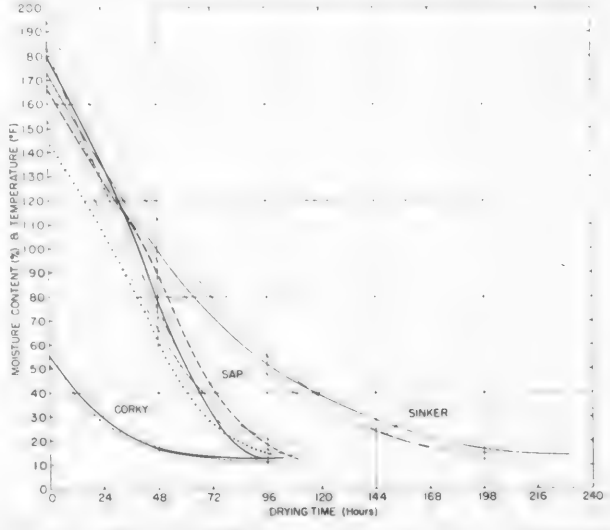

Figure 7.—DRYING CURVES for cork, sap, and sinker types of white fir in seven experimental kiln runs.

Table 1.—MOISTURE CONTENT AND TYPE OF WOOD IN EACH SEGREGATION OF WHITE FIR—COMBINED SAMPLE FROM THREE CALIFORNIA MILLS

Segregation and type of wood	Moisture content per sort		Type of wood per sort	
	Range Percent	Average Percent	Range Percent	Average Percent
Cork segregation				
Cork wood	58.7–112.6	81.0	79.8–80.6	80.3
Sap wood	58.3–112.5	85.0	0 –20.2	12.9
Sinker wood	109.0–180.0	110.9	0 –19.4	6.8
Weighted average or total		83.5		100.0
Sap segregation				
Cork wood	71.3–105.7	88.2	26.1–48.6	36.0
Sap wood	119.2–259.1	170.2	38.0–73.9	59.5
Sinker wood	134.6–159.3	143.4	0 –13.4	4.5
Weighted average or total		139.5		100.0
Sinker segregation				
Cork wood	69.2–127.6	102.3	6.1 31.4	15.6
Sap wood	147.6–166.5	156.4	3.6–32.6	21.3
Sinker wood	150.1–167.4	158.1	36.0–90.3	63.1
Weighted average or total		144.6		100.0

Table 2.—DRYING TIME, IN HOURS TO 20 PERCENT MOISTURE CONTENT

Kiln run	Segregation			Range of kiln condition	
	Cork Hours	Sap Hours	Sinker Hours	Start D.B.–W.B. Dep. Degrees F.	Finish D.B.–W.B. Dep. Degrees F.
1[1]	----	102	-----	160– 7	180–40
2[1]	----	114	-----	160–15	180–40
3	42	84	158	160–15	180–40
4	42	82	-----	170–15	185–35
5	40	86	-----	180–15	180–40
6	----	-----	156	170–15	185–40
7	----	78	176	170–15	185–35
Average All runs	40.6	91.0	163.3		
Average "Pure sorts"	40.6	82.5	163.3		

[1]Commercial sorts.

percent when surfaced, ranging from 8.6 percent for sap in run No. 7 to 14.4 percent for sinker in run No. 3.

The regrading of the 8-foot cork planks showed that no degrade developed during kiln drying. In both the sap and the sinker planks, however, some degrade developed. Reasons for degrade were split and loose knots, checks or splits, warp (cup), and shake. These defects are associated with the overdrying of dimension as well as with the kiln schedule used. We have no measure of the kiln drying degrade at a final moisture of 15 to 20 percent, which is considered desirable for surfacing dimension material.

Internal checks (honeycomb) developed in run No. 6 but were revealed by resawing rather than by surface examination alone.

Severe degrade developed during surfacing primarily because boards split in the planer. For instance, cork lumber which showed no degrade as rough-dry showed roller-splitting in over one-half of the 8-foot planks when surfaced.

This measure of degrade serves as a rough check on the schedules used, but fall far short of the accuracy one would expect from a study to determine degrade.

Effect of Storage

Bulk or solid storage greatly improved the uniformity of moisture content of the ponderosa pine lumber. One hundred and twenty-four boards were pulled from the dry chain to make up the first unit, containing 2,720 board feet. The length of red marks ranged from a mark 1 inch long up to one continuous mark 23 inches long across the width of individual boards. Some boards had discontinuous marks, usually no more than 2, although 2 boards were recorded as having 3 marks. These broken marks indicate wet streaks in the lumber.

The aggregate length of marks when first metered equaled 1,138 inches, or an average length of 9.2 inches per board.

After one week of shed storage of the lumber in a solid pile, only 10 boards were marked with red ink as having a moisture content over 12 percent when remetered, an improvement of 92 percent (table 3). The aggregate length of the red marks on these 10 boards was 31 inches, or an average length of 3 inches per board. The average for the total pile was .25 inch per board, an improvement of 97 percent.

Ninety-nine boards were pulled from the dry chain to make up the second full unit. No footage was recorded. The length of red marks ranged from a mark 1 inch long to one continuous mark 22 inches long across the width of individual boards. Sixteen boards had discontinuous marks. The aggregate length of marks when first metered was 955.5 inches, or an average length of 9.6 inches per board.

After two weeks of shed storage of the solid pile, only 6 boards were remarked as too wet when again metered, an improvement of 94 percent. The aggregate length of marks was only 20 inches, or an average length of 3.3 inches per board. The average for the total pile was 0.20 inches per board, an improvement of 98 percent.

Conclusions

Green-Chain Segregation

The commercial segregation of white fir into drying sorts is not clear cut. Each segregation contains some of each type of wood. The inclusion of two or even three types of wood within the same board precludes 100 percent accuracy. These "mixed" boards should be placed in the segregation that will minimize loss of grade and value during drying and remanufacture. Improved guidelines for more accurate segregation may develop from an uncompleted part of this study designed to measure the loss resulting from too high and too low a moisture content in kiln dried lumber.

The green moisture content of white fir varies greatly from the low moisture content cork-type wood to the high moisture content sap and sinker-type wood. However, the moisture content of an out-of-place wood type is more like the segregation in which it is found than the same wood type in a pure segregation. Cork-type wood in sinker segregation has a higher moisture content than cork-type wood in the cork segregation and similarly, sinker-type wood found in cork segregation has a lower moisture content than sinker-type wood in the sinker segregation.

Table 3.—EFFECT OF STORAGE ON MOISTURE CONTENT OF SOLID PILED LUMBER

Unit of measure	Unit 1 (stored 1 week)	Unit 2 (stored 2 weeks)
Number of boards		
Number unacceptable	124	99
Number acceptable when remetered after storage	114	93
Percent acceptable after storage	92	94
Length of line		
Inches per unit when first metering	1,138	955.5
Inches when remetered after storage	31	20
Percent improvement after storage	97	98

Figure 6.—ONE ELECTRODE of automatic moisture meter with inking device for marking lumber that is above or below preset moisture limits.

Drying Time

Because of the great differences in green moisture content and differences in drying rate between sapwood and heartwood, the three types of white fir require greatly different drying time. The ratio is very close to 2–4–8 for cork, sap, and sinker, respectively. The difference of drying time of the three types of wood clearly indicates the need for accurate segregation on the green chain if a small range of final moisture content is necessary.

The percent of out-of-place wood is least in the cork segregation, and the final moisture content of a kiln charge of cork segregation should be expected to be fairly uniform. The sap-type wood in this segregation should dry very nearly as fast as the cork-type wood. The sinker-type wood in the cork segregation will most likely be insufficiently dried, even though the green moisture content is lower than for sinker-type wood in the other two segregations.

The percent of out-of-place wood is greatest in the sap segregation. The cork-type wood in this segregation will no doubt be overdried when kiln-dried in a commercial kiln operating on a sap schedule, but less so than the 2–4–8 ratio of drying time would indicate. The sinker-type wood in this segregation may dry fairly well along with the sap-type wood because of its relatively low green moisture content.

The sinker segregation is apt to cause the greatest problem in kiln-drying to a uniform final moisture content. The cork-type wood in this segregation, even at a green moisture content of 102.3 percent will dry in a shorter length of time than the sinker-type wood, and the sap-type wood at a green moisture content of 156.4 percent will also dry in a much shorter length of time than the sinker-type wood.

The schedules recommended by the U. S. Forest Products Laboratory are probably as severe as can be used with safety. There appears to be little opportunity to greatly improve the drying time by further manipulation of the dry bulb and wet bulb temperature. In fact, sinker segregations dried by schedules starting at 170° F. dry bulb and ending with 185° dry bulb showed some internal checking (honeycomb) when resawed. The somewhat milder schedules recommended by the U. S. Forest Products Laboratory in their latest publication on kiln schedules are more suitable for sinker-type white fir Shop and Molding grades and other items where this type of defect greatly reduces the value of the finished lumber.

These white fir drying studies show conclusively that drying time is the most important factor in the kiln schedule. Drying to the desired final moisture content can be attained by greater attention to control of the drying time. Drying to the desired range of final moisture content is directly related to the uniformity of the charge as it is loaded into the kiln.

Greater accuracy in marking white fir on the green chain for pulling into drying sorts will improve the uniformity of the kiln charge. The basis or criteria for making the segregations should be carefully analyzed in light of these findings to reduce the dollar loss due to overdrying or underdrying of mispulled boards, and of areas in boards containing two or more types of wood.

"Equalizing" in the dry kiln to reduce the variations in moisture content of the charge at a final moisture content of 15 to 19 percent is seldom done because of the practical difficulties of maintaining the low wet bulb depression required, and the extra cost. Equalizing is usually too costly for relatively low value white fir dimension.

Effect of Storage

Bulk or solid storage of kiln dried lumber has a beneficial effect on the moisture distribution within individual pieces, as areas of both high and low moisture content are equalized. This equalizing of moisture should reduce losses in subsequent remanufacture. Storage of kiln dried lumber is suggested as a practical method of improving the range of moisture content. Though storage of kiln dried lumber improves the final moisture content considerably, it can hardly be expected to correct the ills of poor drying resulting from improper segregation or improper operation of the kilns.

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THE FUTURE OF

Softwood Lumber in Eastern Canada

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Will there be a demand for the product? 2) Will there be raw material to meet the demand? 3) Can costs be maintained in a competitive position? 4) Will returns encourage reinvestment and new capital? 5) Are marketing and research programs well organized?

WHILE WE ARE TO CONSIDER THE future of the softwood industry in the East or Northeast, we might first examine the factors governing the future of any industry.

1) Will there be a demand for the product being reviewed? Will this demand be increasing or decreasing and at what rate?

2) Will there be a continuity of raw materials to meet the demand?

3) Can cost of operations be maintained in a competitive position and supply the needs as required?

4) Will the return on investment be sufficiently attractive to encourage re-investment and to gain new capital?

5) Are the marketing and research programs sufficiently organized to capture the share of market indicated by the demand?

If we examine these factors one by one, the future of the softwood industry may be self-apparent.

Demand

To those of us close to the day to day operations it seems that many substitute products are replacing wood. More importantly, the lower grades formerly used in wood boxes, crating, rough boxes, etc., are experiencing a slackening market because of the inroads of fiber cartons, veneered crates, cement rough boxes, and others. Additionally, we are finding that certain species are becoming less competitive because of cheaper lumber, either from western Canada or from the southwest United States. Specifically, eastern hemlock, red pine and white pine *(Pinus strobus)* seem to be facing price competition that is becoming more difficult to meet.

On the other hand, economic forecasts by the Royal Commission on Canada's Economic Prospects (Gordon Commission—1956 and later) and the Stanford Research Institute Report, undertaken for the Weyerhaueser Timber Company and published in 1954, indicate marked increases in population in the next 15 to 20 years. This population will require more housing, more packaging, and more lumber of all kinds, particularly for housing materials.

Table 4, page 35 of the S.R.I. survey contemplates a marked reduction of lumber used per unit of housing, but an overall increase from 1960 to 1975 of approximately 20 percent. This survey, of course, covers the whole of the United States. In the summary of major conclusions it states that increasing prices of lumber encourage cheaper substitutes such as concrete, hence limiting or decreasing lumber's participation. Finally, it concludes that the East will show moderate increased demand for lumber and pulp uses of timber but a decline in total wood use.

During the years since the forties the total market that could use lumber has increased and with increasing population will continue to increase. Lumber's participation, while increasing in volume, is shrinking as a percentage of the total possible market. In other words, a bigger pie divided into more pieces.

Despite these indications of dropping per capita use and a smaller share of the available market, the Gordon Commission forecasts a domestic demand of 5.8 million board feet by 1980 compared to 3.7 million board feet in 1954. Similarly they forecast an increase in exports from 3.6 to 5.8 million board feet.

Because eastern species, in the main, move in a fairly narrow market area, we are basically interested in the Eastern domestic and overseas export markets. It seems reasonable to assume that the Central and Atlantic provinces will continue to expand equally with the rest of Canada in population and in product demand as well.

We, therefore, can conclude that there will be an increasing demand for softwood, which could be limited by our lack of resourcefulness in solving problems that reflect on our competitive position, and customer acceptance of our product.

Continuity of Supplies

There seems to be a dearth of reliable figures on future supplies of standing timber. The S.R.I. report suggests that the East's relative position of supply to demand by 1975 will be little changed. An interesting comment about the Southern United States occurs on page 22 of the report.

"In the South, however, there is only limited evidence that small producers, who account for the major portion of total lumber production (as distinguished from pulp production) have made provision for future large-scale saw-timber supplies."

Despite the differences in tenure and specie, I believe that the same comment is true of some sawmills in Eastern Canada. In Canada, the bulk of our timber is owned by the Crown, and cutting is regulated under several systems of tenure by each Province. In the East, the Maritime Provinces contain the most free-hold timber. In general, the Atlantic and Central regions were cutting in the year 1954 about 61 to 69 percent of the allowable softwood cut from accessible forests.

Based on present forest operating conditions and after making allowances for insect, disease, and fire losses, the total annual depletion by 1980 will be approximately 52 percent of the total wood available in the Atlantic and 61 percent in the Central region. We can expect greater yields

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[1] Presented at Session X, Lumber Manufacturing, FPRS 14th Annual Meeting, June 7, 1960 in Montreal, Canada.

ENGINEERING RESEARCH must start in the forest and continue on through the sawmill. One of the most important factors influencing the future is the need for specially designed equipment, such as this Bombardier Processing Unit which receives whole trees and converts them to 4-foot bolts and loads them on truck pallets.

from improved forest management to add to our reserves.

These figures, of course, are in general volumes. Each of the Eastern Provinces have different species, and therefore different problems of production. For instance eastern hemlock and red pine are facing, at least for the time being, extreme price competition, and hence forest cropping might be reduced. White pine in Ontario is facing a containing of production, awaiting the time when growth can catch up with cutting pressure. It is expected that concentrated forest management will restore this balance in 10 or 15 years.

Despite these considerations, I believe we can conclude that we have a supply available to meet the forecast of demand by 1980.

Competitive Position

Any comment about the future competitive position is mostly conjectural because there are so many "ifs" involved. Any studies of importance have indicated an apparent trend for lumber to price itself in such a manner, as to attract competition, or more bluntly—to price itself out of the market. Those of us in the industry can testify to this truth. Among the reasons that costs will continue to increase are—

1) The likely continued increase of stumpage.

2) Increased logging costs due to logging areas less accessible; less volume per acre resulting from the impact of management plans; timber stands of decreasing density per acre; higher transportation costs and the declining size of trees being cut.

3) Continued costs of manufacturing because of declining log sizes and increasing labor rates.

4) Distribution costs have shown no sign of abating.

Does this mean that we have no recourse to modifying this trend? I don't believe so. However, to realize the magnitude of the problem we should refer to some statistics. Turning to catalogue 35–204, Dominion Bureau of Statistics 1957, we find that reporting sawmills in Canada grew in number from 5,295 in 1945 to a peak of 8,283 in 1952 and then declined to 6,276 in 1957.

In Eastern Canada, excluding Newfoundland, the number of mills declined from 3,956 in 1954 to 3,237 in 1957. The average number of employees was 6.1 per mill, and they produced $60,040.00 of product per annum or by estimate approximately 750,000 board feet of lumber. Despite this average production per year, available statistics indicate that 25 percent of our mills produced less than 200,000 board feet per year; another 19 percent less than 500,000 board feet; another 11 percent less than 1,000,000 board feet. Of total lumber produced in Canada, 2.4 percent of the mills produced 49 percent of the lumber. In these figures lies the root of our problem. Obviously these data suggest that many of these mills have little capital invested. They can get in and out of the market at will. More importantly, there is a tendency to create waste; to produce an inconsistent product; to impede the investment in more efficient mills by reason of the price impact of this type of product on the market, which of course reduces profit and incentive to invest new capital. Quite apart from price, lack of uniformity of grade, manufacture, and seasoning, encourages some users of wood to seek substitute materials.

In the short term, these smaller units, where the proprietor often takes his profit as wages, will continue to exist. In the long term, I am certain that both the small mill and the very large mill will disappear.

In their place will be medium sized mills cutting from 15 to 22,000,000 board feet per year. These mills will operate the year round and for maximum equipment utilization on a multi-shift basis. Most of our lumber will be kiln dried, which will give better control of the product, but more importantly will reduce the gamble on long-term inventories. Additionally, a mill can be more flexible and more sensitive to customer requirements.

Perhaps the most important development will be the conversion of sawmill residuals into pulp chips. Admittedly we have many problems to overcome in the East of which distance from pulpmills is the most important. There is a definite trend in this direction, and it will continue in ever increasing degree. Better utilization in the woods is also needed in order to hold or reduce sawlog costs.

The industry should watch carefully an operation at Braeside, Ontario, on the Ottawa River, west of Ottawa. In this town, the oldest white pine company in Canada, still operated by the founding family, Gillies Bros., has embarked on a courageous course. In brief, they have converted to a western-type operation. They will saw the year round, kiln dry, and rework all their stock. Hence, they will be in the market the year round and can deliver a specific requirement to their customers within six weeks. Logs will be barked and edgings and slabs chipped for pulp chips. Apart from starting up problems, their most difficult problem will be their departure from the normal marketing procedure for white pine, which has existed for years. As with many other eastern species, production is mostly seasonal followed by a drying period and then shipping. Gillies' present plans must envisage a reasonable large movement of stock each month against an order file. This marketing approach, although not new, has many years of accepted practice to overcome.

Provincial and State Governments can help the industry but not necessarily with money. For instance they can be ahead with legislation on highway traffic which would allow heavier

equipment on the highways during certain seasons. They can look ahead to cheaper and more co-operative scaling and other practices in order to encourage mechanical operations. They must, in fact, examine every facet of their connection with the forest industry in order to assist in containing costs.

Can costs of operations be maintained in a competitive position? Only our collective desire and ingenuity will determine this.

Will the return on investment encourage new capital?

Again, referral to D.B.S. figures would indicate that capital employed has fluctuated marginally in the last 5 years. The answer to the question then, is—at present levels with present methods—"No". Gillies Bros., however, would seem to have answered this question with a resounding—"Yes". Apparently then, this is a question that will receive varying answers depending on the individual circumstances.

Engineering and Marketing

Relatively, Marketing and Engineering programs in the east are practically non-existent. Certainly compared with the manufacturers of substitute materials, this is true. Yet the comparison is not quite fair. As indicated previously, our producers are numerous and small. This makes it impossible for small units to carry out extensive programs of engineering or marketing. Our competition is usually a small group of large producers, who can mount such programs with ease.

Notwithstanding the problems arising from the basic structure of our industry, we may find the indicated decline per capita use accelerated, unless we can effectively solve engineering and marketing problems. This basic structure of numerous small mills probably indicates a need for expanded assistance from government laboratories. Our silent partner has a large and vital stake in our industry in the form of taxes, quite apart from the impact on the economy of the forest and sawmill worker.

Engineering research must start in the forest, and continue on through the sawmill. Of all the problems to be faced the following are perhaps most important.

1) The need to reduce or at least contain the labor element ratio to total value of logs. As our timber stands become less dense, and logs smaller, the problem becomes more acute. This probably suggests more capital equipment for logging.

2) The need for more equipment designed for logging rather than adapted from construction equipment.

3) The need for more integration in logging in order to reduce forest waste and to increase yield per acre.

4) The need for tree length logging, and improvements in portable barkers and chippers.

5) The need to increase the production per man hour in sawmills, which for many reasons, including the use of smaller logs, has been declining.

6) The need to keep sawmill production at such levels that wage structures, which are lower than some other forest industries, can be maintained high enough to attract the best skilled men.

7) The need to integrate sawmill operations to several products in order to reduce waste to a minimum. A more positive approach is to utilize the log to the maximum possible.

8) The need to look beyond production engineering problems to the problems of the user of wood. For instance, who can forecast the increased demand for wood siding if painted surfaces were capable of competing with other products in the maintenance of these surfaces.

The foregoing is an impressive list of engineering problems but not beyond our power to overcome. It is in marketing that the lumber industry has failed the most. Not so much for current production but for the extension and retention of our share of the market in the future. In the main, eastern lumber marketing has changed little over the last 25 years. We have left changes in demand in the hands of the user, rather than attempting to create demand. Too often, poorly seasoned, poorly graded, and poorly manufactured stock has been offered for sale. As a result, the ultimate consumer has been soured on all lumber and has sought substitutes. Too often, the manufacturer has been divorced from the consumer. As a result intermediary sales agents, wholesalers, and retailers have only sold part of the product. In many instances they are selling competitive products to the detriment of lumber. Had manufacturers been more sensitive to customer needs, they might have been able to change methods and product to suit the need. As it is, the marketing intermediaries either sell part of the mill production or sell an acceptable substitute.

Many marketing problems might be overcome by the development of more concentration yards. The small mills would sell to such yards because they have neither the quantity nor the personnel to grade or sell stock other than mill run. A concentration yard, properly run, can produce a better graded and manufactured product to the increasing satisfaction of the consumer. This, in the end, would help to provide market stability.

The manufacturing industry should recognize once and for all that the retail lumber dealer is mis-named. He is a "retail building products and hardware dealer." Lumber is one of the products he sells. If he can sell something else at more profit, he will do so. Why shouldn't he do so? After all, to stay in business profitably he must satisfy the desires of his customers. We cannot reverse overnight thinking and practices developed over the years but we can make a start to this problem of marketing. I suggest for your consideration the following steps.

1) A comprehensive advertising campaign in general and by species. I am happy to note that a program of this kind is well started in the United States, and a similar program is gathering speed in Canada.

2) See to it that products advertised are available to the consumer. There is nothing worse than being unable to purchase a product that you want to buy.

3) See to it that our products are properly graded and identified. In this regard, the recent F.H.A. ruling in the United States that lumber going into housing must be grade marked is probably a big boost to lumber acceptance. There are problems of course, but the long-term effects will be beneficial.

4) Get closer to your ultimate consumer. To do this the industry may have to take positive action on distribution of lumber at retail level.

5) Commence a sound public relations program stressing the importance of the industry, its contributions to the economy, and its impact on other resources, such as water.

Admittedly the basic industry structure of large numbers but small producers creates a special problem for us. But, as I see it, we have only two courses open to us—progress, or gradually become less important.

I believe in 5 years or so you will see less marketing agencies but larger ones. You will see more integration manufacturing and ultimate distribution. You will see co-operative specialty marketing. You will see more manufacturing by producers of pre-cut items.

Only time can tell the future of the softwood industry in the northeast. But diligent and intelligent application of our collective efforts the forecast can be—"cloudy intervals with some showers clearing late in the day with sunshine following."

THE USE OF BARK EXTRACTS IN

Cold-Setting Waterproof Adhesives[1,2]

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Contribution No. 53

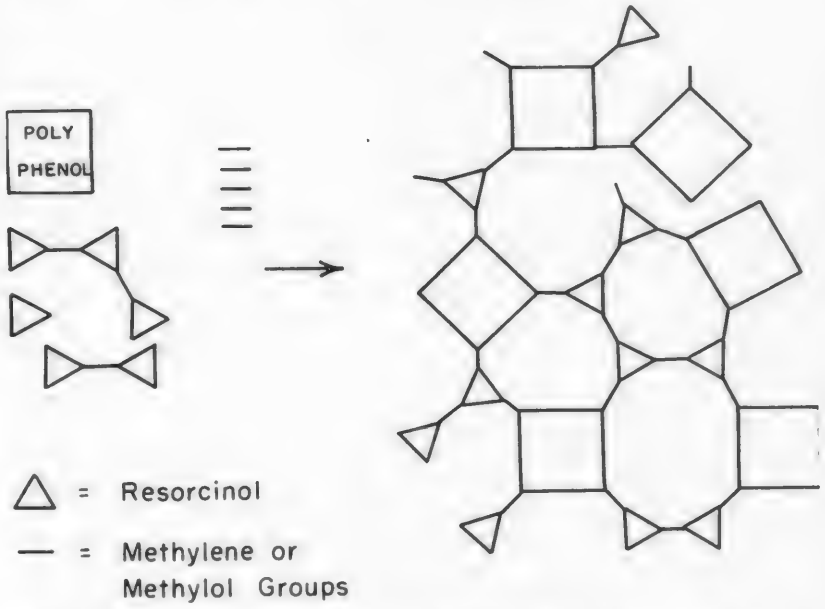


Figure 3.—SCHEMATIC DIAGRAM of the heterogeneous reaction of polyphenolic bark compounds with formaldehyde and resorcinol-formaldehyde resin to form a crosslinked polymer.

IT HAS ONLY BEEN DURING THE PAST 20 years that much attempt has been made to utilize the polyphenolic components of bark or wood in the preparation of resins for use in adhesives or plastics. Coniferous tree barks in particular provide a rich and replenishable source of material that is reactive to formaldehyde and has potential value in the manufacture of phenolic and related resins. An excellent and current review of bark utilization was recently published in the *Forest Products Journal* (11).

Work previously reported in the *Journal* (4) described how a thermosetting adhesive for exterior plywood was prepared by combining bark extract and polymethylolphenol. This current work demonstrates how the bark extract, designated as "HT-120," can be mixed with a resorcinol-formaldehyde resin and additional formaldehyde to form cold-setting adhesives that produce high-strength, waterproof bonds in wood.

Adhesives containing 30 to 60% of bark extract met pot-life and assembly-time requirements of laminating industries, and test bonds passed requirements of the major performance standards.

Polyphenolic Intermediates from Bark

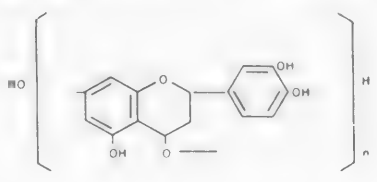
Chemical Extraction of Bark: About 10 years ago, a study of various combinations of physical and chemical techniques for extracting the polyphenolic components of bark was started at Rayonier's Olympic Research Division. The bark of western hemlock *(Tsuga heterophylla)* was used as the main raw material, although bark from other coniferous tree species was also studied. Much of the bark supply was obtained from water-floated logs, and thus had already lost some water-soluble tannins. Extraction of hemlock bark with hot water on a fairly large scale and under autoclave conditions yielded at best only 8 to 10 percent extract.

Extraction with alkaline chemical reagents (5, 15) in a manner comparable to that used in the alkaline pulping of wood resulted in increased yields of extracts and, within certain limits, yields were directly proportional to extracting chemical usage, temperature, and time. Strong bases, such as sodium hydroxide, appeared to be inefficient as extracting chemicals, yielding mixtures of polyphenolic compounds, lignin-like materials and alkali-soluble carbohydrates. On the other hand, extraction with weak bases, such as aqueous ammonia, gave products with reproducible high reactivity that were obtained in yields of 25 to 30 percent, based on the dry bark weight.

Ammonium salts of phenolic compounds are unstable and lose ammonia if concentrated or dried. When recovered, the ammonia extract was found to be mostly water insoluble. For certain uses, the ammonia extract was converted to a water-soluble sodium salt form by treatment with sodium hydroxide prior to isolation.

HT-120 might be described simply as the spray-dried sodium salt of an ammonia extract of western hemlock bark. This phenolic intermediate has been produced in pilot plant quantities up to 100 tons.

Composition and Properties of HT-120: HT-120 may be considered as a mixture of similar polymers, possibly differing only in degree of polymerization. Viscosity properties were found to be controllable to within fairly narrow limits. Evidence of this type points to some degree of uniformity of molecular weight and reactive species. The following flavonoid structural unit is illustrative of the type of phenolic functional groups that are believed to be present in HT-120:



Phenolic hydroxyl groups may be detected by ultraviolet spectroscopy. A procedure that was used successfully to estimate

The authors: Franklin W. Herrick is leader of the Silvichemicals and Resins Group of the Research Division; he holds a PhD from Michigan State. Romeo J. Conca holds a PhD from Yale, and heads up the Pulping Development Group.

[1] Presented at Session VIII, Chemical Utilization, FPRS 14th Annual Meeting, June 7, 1960, in Montreal, Canada.

[2] The authors gratefully acknowledge the contributions to this work of other members of the staff of the Olympic Research Division of Rayonier; especially, Drs. Andrew Beélik and Igor Sobolev.

Figure 1.—GELATION TIMER—Automatic stirring and timing device gives record of gelation time in minutes.

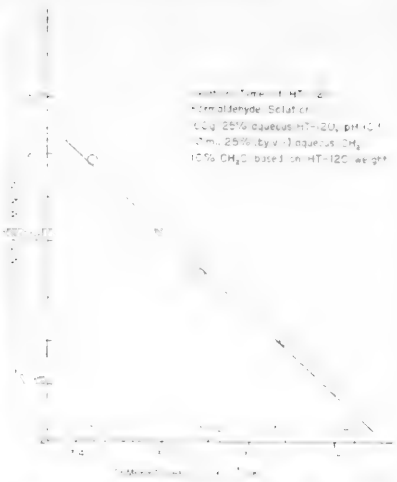


Figure 2.—LOGARITHM OF GEL TIME plotted against reciprocal of absolute temperature.

the relative amount of phenolic hydroxyl present in bark extracts is based on measurement of the shift or difference between the spectra of dilute alkaline and neutral or acid solutions of a given extract (7). By this technique, the phenolic hydroxyl content of HT-120 is about 10 percent.

Aqueous solutions containing as little as 15 percent HT-120 are very sensitive to formaldehyde and will become solid gels on standing at room temperature in the presence of 1 to 2 percent formaldehyde, based on the bark extract weight. In the study of a large number of HT-120 samples from pilot plant production, it was convenient to use a 25 percent solution of HT-120 as the basis for measuring both relative viscosity and formaldehyde gelation time. These solutions were prepared by adding the bark extract to water in a high speed mixer. If necessary, a small amount of concentrated acid or alkali was then added to adjust pH to 10.5. Viscosity was determined with a Brookfield viscometer. On a 25 percent total solids solution basis, average viscosity was about 2 poises at 77°F. (25°C.), and variability was ± 1 poise.

The formaldehyde gelation time of a bark extract may be used as a measure of reactivity. In order to determine this property of HT-120, a 100 gram sample of the viscosity solution was treated with 10 milliliters of 25 percent (by volume) aqueous formaldehyde, or 10 percent formaldehyde based on HT-120 weight. After mixing, the sample container was placed in a constant temperature bath at 70°C. Other standard temperatures for gelation time measurement were 25°, 50° and 90°C. The sample was stirred occasionally by means of a plunger inserted through the cap of the container or by use of an automatic stirring and timing device (Fig. 1). In the first case, the gelation point was determined visually, and the time required to reach this point was recorded as "gelation time". In the case of the automatic timer, the plunger was disengaged automatically and the device provided a record of gelation time in minutes, as soon as viscosity became great enough or gelation occurred.

The formaldehyde gelation time at a standard temperature appears to be quite characteristic for different bark extracts. Although single gelation time values are useful in the rapid estimation of reactivity, a better picture may be obtained if a plot of gelation time measured at several temperatures is made. In Figure 2, the logarithm of gel time is plotted against the reciprocal of absolute temperature. This plot yields essentially a straight line, which from polymer chemistry relationships indicates normal network polymerization between HT-120 and formaldehyde. The slope of this line and its position on the graph may be used to calculate relative activation energies for the reaction of formaldehyde with different bark extracts under various conditions.

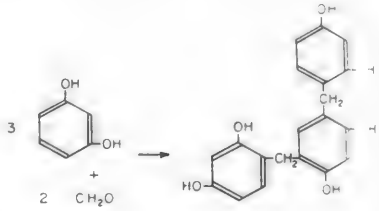
By most standards, the adhesive properties of HT-120-formaldehyde solutions are not too remarkable. High viscosity and very short pot-life rule out the use of mixtures containing over about 30 percent total solids. The following example shows what may be done along this line.

A 100 gram sample of 30 percent solution of HT-120 in a solvent medium of 70 percent water and 30 percent ethylene glycol was mixed with 6 grams paraformaldehyde and 7 grams walnut shell flour. The mixture had a pH of 10.7, a viscosity of 100 poises and gelled in 30 minutes. This mixture was treated as a cold-setting adhesive in the same manner as will be described later. Average dry bond strength (Douglas-fir) was 1398 psi with 70 percent wood failure. Strength after a cold water soaking and drying cycle was very poor, although no delamination occurred. The approach of using HT-120 in combinations with synthetic phenolic resins had been successfully used in previous work (4). From a structural and reactivity standpoint, it seemed reasonable to believe that HT-120 would behave even better in combinations with resorcinol-formaldehyde resins.

Resorcinol-Formaldehyde Resins

Structure and Preparation: Although the history of resorcinol-formaldehyde condensates extends back to the late 1920's, recognition of their worth as adhesives for wood has come only during the past 15 years (2, 3, 12).

In its reaction with formaldehyde, resorcinol is the most reactive of all phenols. The reaction is exothermic, but it can be controlled by cooling and slow addition of formaldehyde with good mixing. If more than one mole of formaldehyde is reacted with one mole of resorcinol, the reaction will proceed even at room temperature in a matter of a few hours until a crosslinked, insoluble, infusible polymer is formed. This unique property of cold-setting under essentially neutral conditions distinguishes resorcinol from other phenols. Usual practice calls for reacting resorcinol with 0.5 to 0.8 moles of formaldehyde in aqueous solution and in the presence of mild acid or alkaline catalysts to form a stable low molecular weight resin, known as a novolac. This resin is permanently soluble and fusible. A simplified illustration of this reaction may be written as follows:



If more formaldehyde is added to a resorcinol-formaldehyde condensate of this type, the reaction will continue with the formation of crosslinked, three-dimensional structures. This is essentially what happens in the glue line when wood is bonded with a resorcinol-formaldehyde resin adhesive.

The technique of preparing resorcinol-formaldehyde resins and copolymers with phenolic resins is described in the patent literature (13, 14). In preparing adhesive formulations containing bark extracts, it was necessary to have resorcinol-formaldehyde condensates of known composition. The following preparation is easy to duplicate, and it required a minimum of apparatus:

A reaction vessel equipped with a reflux condenser, thermometer, efficient stirrer, and a jacket with steam and cold water connections was charged with 110 parts by weight of resorcinol and 22 parts of water. Stirring was started and 22 parts of 37 percent formaldehyde were added gradually. This mixture was then carefully heated until refluxing occurred. After 15 minutes at reflux, an additional 33 parts of 37 percent formaldehyde were added at a rate so that refluxing was under control. Following this, heating was continued for an additional 25 minutes. The syrupy liquid was then cooled to room temperature.

This preparation contains 65 to 67 percent total solids and, on standing, gradually turns into a viscous paste. In subsequent discussion, this resin will be referred to as RL. For the sake of brevity, the letters R and RP will be used to designate resorcinol-formaldehyde and phenol-modified resins, respectively.

Performance Standards for Cold-setting Waterproof Adhesives: The development of resorcinol resin adhesives was hastened

nsiderably by the critical need for completely waterproof adhesives during World War II. Eventually, government (military) ecifications were drawn up to cover the rformance of adhesives of this type. The ecification known as MIL-A-379B (8) is idely accepted in the United States as a ide for the performance of adhesives in minated timbers or other glued structures at are to be exposed to exterior weather- g conditions. The military specification r Douglas-fir wood laminates MIL-W-38B, Ships (9) was of particular inter- in the present study, since one of the in objects of this work was to develop waterproof adhesive for laminating industries using Douglas-fir, hemlock, pine, ruce, and similar softwoods. In addition tests based on the above specifications, me of the tests used in this study were se of the commercial standard for exrior plywood (1).

Some of the requirements considered were as follows:

1. The resin (liquid) component of the adhesive should have reasonable shelf stability, say 6 months at 73°F.
2. The glue mix should have a working life or pot-life of at least 2.5 hours at 73°F., measured from the time when the resin and hardener components are mixed.
3. The pH of the set adhesive film should not be less than 3.5 nor more than 11.0.
4. The adhesive should be able to develop an average strength of 2800 psi when used to bond hard maple wood. In Douglas-fir, the average block shear strength between laminations should not be less than 1050 psi, with at least 75 percent wood failure.
5. The adhesive bond should resist delamination during three cycles of a water-soaking treatment under vacuum and pressure, followed by drying. This test is performed on 3-inch sections of laminated timbers, and the stages in each cycle involve:
   a. Submersion of test specimens in water under a vacuum of 20 to 25 inches of mercury for 2 hours.
   b. Submersion in water under air pressure at 80± psi for two hours.
   c. Repeat stage a.
   d. Repeat stage b.
   e. The specimens are dried for 88 hours in air at 80° to 85°F. and 25 to 30 percent relative humidity that is circulated at a rate of 450 ft./min.

Delamination as measured along end-grain (cross-section) glue lines should not exceed 8 percent of the total glue line length.

The growth of timber lamination into a specialized industry where complex wooden structures, such as arches, are manufactured to exacting specification has imposed new requirements on the adhesive. For most industrial applications, the adhesive must have wide tolerance to open-assembly time which may range from 20 to 70 minutes. The adhesive should be easy to spread and easy to clean up prior to setting. Bearing these factors and performance standards in mind, it is now possible to discuss the preparation of adhesive combinations of HT-120 bark extract and resorcinol-formaldehyde resins.

Experimental Adhesives Containing HT-120

The reaction of HT-120 with formaldehyde might be viewed as the coupling of a large inflexible polyfunctional molecule with methylene units that may be too small to form links across much distance. If resorcinol is added, trimethylol resorcinol and polymethylolresorcinol derivatives are formed that are also capable of reaction with HT-120. Since these molecules are large and more flexible, there is greater potential for reaction with the formation of high strength crosslinked structures. Figure 3 illustrates this reaction although the heterogeneous polymer would actually be three-dimensional instead of planar, as shown.

Preparation of Adhesive Base Solutions and Glue Mixes: In addition to the standard laboratory resin (RL), three commercial straight resorcinol resin adhesives (R1, R2, R3) and three commercial phenol-modified resorcinol adhesives (RP1, RP2, RP3) were used in formulations with HT-120. These mixtures were prepared by blending the desired amounts of each component, measured in parts by weight, in a high-speed mixer. Various solvents or other agents were also added at this stage. Tests performed on the resulting solutions included: percent of total solids, determined with the aid of a Cenco moisture balance using a drying time of 40 minutes and a setting of 110 volts; pH; and viscosity measured with a Brookfield viscometer.

The standard hardener used throughout this study was prepared by blending 44.5 parts by weight of paraformaldehyde with 55.5 parts of walnut shell flour. The amount of hardener added to the adhesive base was calculated so that a slight excess of paraformaldehyde over that theoretically required to give a crosslinked polymer would be present in the glue mix. This paraformaldehyde requirement was estimated roughly as being 20 percent of the resorcinol resin weight and 10 percent of the HT-120 weight.

Glue mixes were prepared simply by mixing 12 to 20 parts of hardener, as required, with 100 parts of the liquid adhesive base, using a spoon, until a smooth mixture was obtained. In determining the pot life of glue mixes, the adhesive base was usually cooled to 60°F. prior to mixing with the hardener, so that the initial glue mix temperature would be approximately that of the 68°F. (20°C.) constant temperature bath in which pot-life test samples were placed. The viscosity of pot-life samples was estimated visually at 15-minute intervals, and it was measured with a viscometer at the start and at 1-hour intervals during the test. Pot-life was defined as the time required for viscosity to build up to 1000 poises. In cases where very short pot-life was encountered (1 hour or less), the gelation time of the sample was recorded as the pot-life. A gelation timer was used as an aid in estimating pot-life when this value exceeded 8 hours.

Evaluation of Adhesives by Means of Exterior-type Plywood Tests: Each adhesive was used to prepare six 8- by 8- by ¼-inch three-ply panels from 0.1-inch Douglas-fir veneer. A glue spread of 50

TABLE 1

HT-120 and Resorcinol-Formaldehyde Resin in Aqueous Solvent at 50% Total Solids Content

Liquid Adhesive Base					Glue Mix[1]	Exterior Plywood Test[2]		
							Boiling Water Cycle[4]	
Ratio HT-120: RL Resin	% HT-120 in Solids	% Total Solids	Viscosity Poises at 77° F.	pH	Pot-life at 77° F.	Knife Test[3] % WF	Strength psi	% WF
2.0	66.6	49.3	1000+	9.5	10 min.	74	126	72
1.0	50.0	48.4	230	9.0	15 min.	87	173	90
0.5	33.4	48.0	41	8.7	15 min.	89	142	89
0.25	20.0	47.3	8.3	8.3	30 min.	96	178	100
0	0	46.8	1.4	8.2	4+ hrs.	99	141	100

[1] 100 g. adhesive base, 20 g. hardener.

[2] Six 1/4 inch 3-ply panels
0.1 inch Douglas fir veneer: 7% moisture
Glue spread: 50 lb./Msgl
10-20 min. closed assembly time
Pressed 8 hrs. at 77° F. and 175 psi
Cured 5 days at 77° F. prior to tests.

[3] Average of 6 values per test.

[4] Average of 30 values per test.

TABLE 2

HT-120 and Resorcinol-Formaldehyde Resin: Effect of Alkalinity on Pot-life and Adhesive Properties

Liquid Adhesive Base[1]			Glue Mix[2]	Exterior Plywood Test[3]				
					Cycle Tests[5]			
					Cold Water		Boiling Water	
Ratio NaOH: Extract	Viscosity Poises at 77° F.	pH	Pot-life at 68°F. hrs.	Knife[4] Test % WF	Strength psi	% WF	Strength psi	% WF
0.1	252	7.6	8+	6	53	14	131	64
0.125	247	8.0	8+	12	107	29	138	64
0.15	22.5	8.5	7	81	176	94	166	98
0.175	10.	8.7	4..	4..	137	48	179	78
0.2	14.5	9.1	3.75	88	210	98	195	97

[1] Ratio of bark extract (calc. as HT-120) to RL Resin = 1.0
40% total solids. Solvent medium: 50/50 water-methanol.

[2] 100 g. adhesive base, 15 g. hardener.

[3] Six 1/4 inch 3-ply panels
0.1 inch Douglas fir veneer: 8% moisture
Glue spread: 50 lb./Msgl
10-20 min. closed assembly time
Pressed 16 hrs. at 77° F. and 175 psi
Cured 5 days at 77° F. prior to tests.

[4] Average of 6 values.

[5] Average of 24 values.

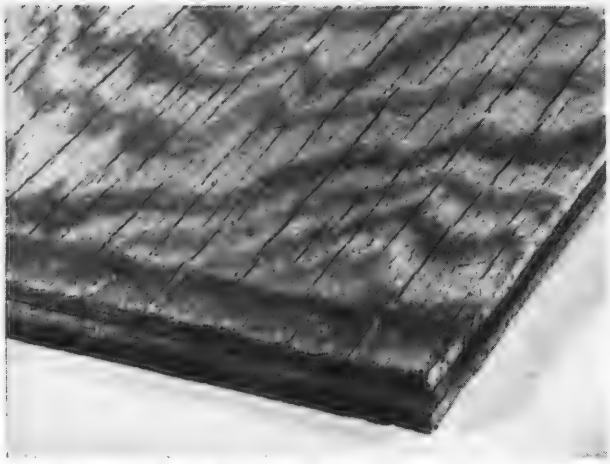


Figure 4.—RESULTS OF FIRST YEAR EXPOSURE: All panels were severely checked, but there was no delamination along the edges.

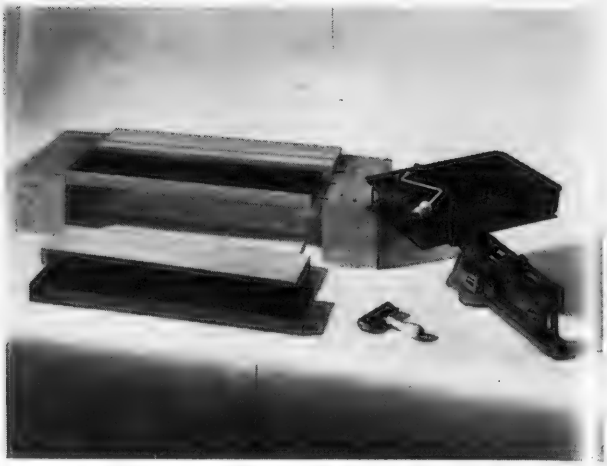


Figure 5.—MOHAIR ROLLER used to transfer weighed amount of adhesive to wood.

lb./Msgl (pounds per thousand square feet, single glue line) was applied to the veneer with a rubber roller. Other pertinent conditions are listed as footnotes to the tabulated data for each group of experiments.

An attempt to prepare adhesives containing 50 percent total solids, and thus approach the solids content (56 to 60 percent) of commercial resins, is illustrated in Table 1. At a ratio of 2.0 HT-120:R1 resin, viscosity was excessive, and in no case was the pot-life of an HT-120 formulation anywhere near the desired 2.5 hours. A "knife-test", as often used in the fir plywood industry, was adapted for the estimation of dry-bond quality. The boiling-water cyclic test was that prescribed for exterior fir plywood (1). Adhesive bonding quality was quite satisfactory, except at the high ratio of HT-120 to resin.

It has been recognized in the technology of resorcinol resins (2, 3) that pH has a remarkable effect on the rate of the reaction between resorcinol or resorcinol novolacs with formaldehyde. Reaction rate is at a minimum under mild acid conditions and becomes progressively faster as pH becomes more alkaline. It has also been established that certain organic solvents, such as methanol, have a strong inhibiting effect on the resorcinol-formaldehyde reaction (6, 10). An adhesive base containing equivalent quantities of bark extract and RL resin at 40 percent solids in a solvent medium of 50 percent water and 50 percent methanol was used in the experiments summarized in Table 2. This bark extract contained a ratio of 0.1 NaOH:extract and additional sodium hydroxide was added to provide various degrees of alkalinity up to a ratio of 0.2 NaOH:extract, the amount present in HT-120. The significant aspects of these data are that as pH increases, pot-life and viscosity go down, but bonding quality goes up. Without the methanol, all pot-lives would have been less than 30 minutes. The high viscosity at pH 7.6 to 8 may have been partly due to incompletely dissolved bark extract which, in turn, could affect bonding quality. In these two experiments, bonding quality was considerably improved by the boiling water test, indicating further reaction between resin components and formaldehyde. At higher pH, bonding quality was practically equivalent in all tests.

Since pot-life difficulties seemed to be resolved by the presence of methanol, the next step was to use more HT-120 in such a formulation. The test results given in Table 3 indicate that HT-120 might replace 50 to 66 percent of the weight of the synthetic resin normally present in a cold-setting adhesive. At the higher usage, pot-life again becomes problematic.

The ultimate test of adhesive bonding quality and durability is to expose a glued structure to actual weathering. An adhesive containing a ratio of 1.0 HT-120:RL resin (Table 3) was used to prepare twelve 14- by 14- by ¼-inch three-ply panels. These panels were mounted in a supporting framework facing southwest at an angle of 45°. Strips from each panel were tested at 6-month intervals. First year exposure results, available in April, 1960, indicated no glue-line degrade, and wood-failure averages were still in excess of 90 percent. Dry-bond strength was about 15 percent lower than original strength. All panels were severely checked, as shown in Figure 4. No delamination could be detected along the edges of any panel.

Evaluation of Adhesives by Tests on Parallel-Grain Laminates: It was somewhat more difficult to reduce the timber-laminating operation to a laboratory procedure. The method adopted was to first evaluate an adhesive or other variable by preparing one or more small two-ply boards with a single glue line. If results were satisfactory, larger four-ply timbers were then prepared for more extensive testing.

Two-ply boards were prepared from ¾-inch, surfaced, edge-grain Douglas-fir of kiln-dried stock conditioned to 8 to 10 percent moisture content. The dimensions of this construction were: 8 inches in the grain direction and 10 to 12 inches perpendicular to the grain. Glue-line faces were sanded lightly prior to gluing to expose fresh wood. Adhesive, corresponding to the desired glue spread in lb./Msgl, was weighed on to the wood and distributed evenly on both glue line surfaces with a rubber roller, previously coated with a standard amount of adhesive. The open-assembly tolerance of the adhesive film was estimated by touch and sight to detect dryness or loss of tack. Assembled boards were pressed in a hydraulic press at room temperature (75° to 77°F.). Other pertinent conditions are indicated with tabulated data.

Four-ply timbers were prepared from substantially clear 2- by 6-inch Douglas-fir lumber that was air-dried to 8 to 12 percent moisture content. This lumber was surfaced on both sides within a few days prior to use, and it was then cut into suitable lengths for assembly into a 2- or 3-foot long timbers. Adhesive was applied with a common paint roller with a mohair cover, the roller being used to transfer a weighed amount of adhesive to the wood, as shown in Figure 5. Inner laminae requiring adhesive on both sides were supported by nails driven in the ends of the stock. Assembled laminates were pressed either in an automatic hydraulic press, as shown in Figure 6, or in portable steel clamps (Figure 7), centered 12 inches apart, and tightened to the desired pressure with a torque wrench.

For the most part, adhesive-bond quality was determined by breaking block-shear specimens under compression loading in a 5000 lb. maximum capacity universal testing machine, using a head speed of 0.05

Figure 6.—ASSEMBLED LAMINATES in automatic hydraulic press.

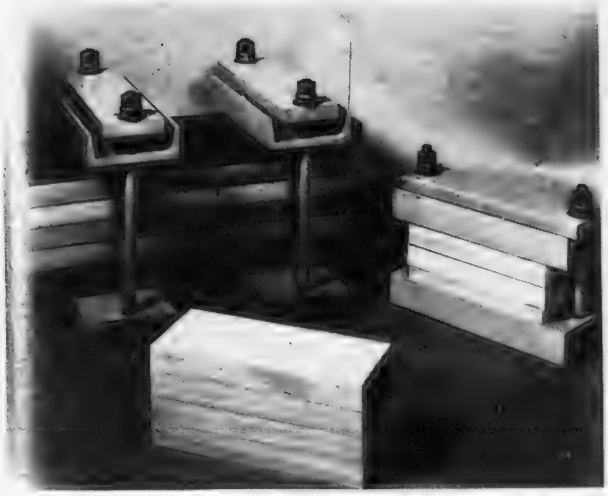


Figure 7.—ASSEMBLED LAMINATES in press between steel clamps.

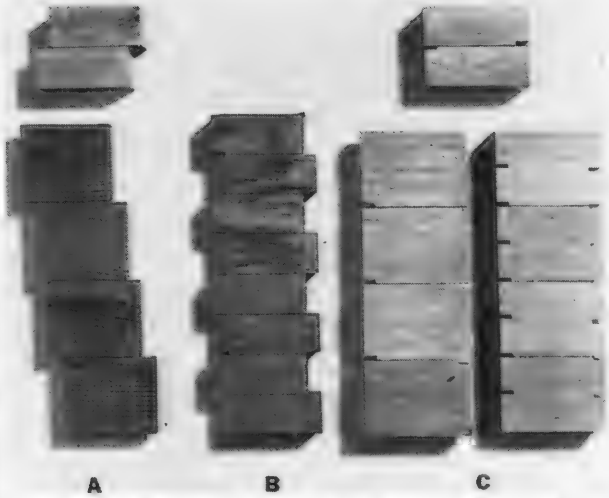


Figure 8.—SPECIMENS WERE CUT: A, in "stair step" style; B, with ¼-inch grooves in alternate plies; C, with ¼-inch kerfs adjacent each glueline.

in./min. Due to the capacity limitation of this machine, it was necessary to reduce the width of block shear specimens to 1 inch instead of the 2-inch wide specimen used in the previously mentioned military specifications. Glue-bond area was thus reduced to 1.5 instead of 3 inches. Two-ply 8- by 10-inch boards were trimmed ¾ inch along each edge and cut into 21 shear specimens. Four-ply timbers were cut into 2- and 3-inch wide cross sections, the latter size specimen being used in vacuum-pressure cyclic tests. The 2-inch wide cross sections yielded four specimens, each having three glue bonds.

Although at the beginning of this work all specimens were cut in the "stair step" manner, as shown in Figure 8-A, this procedure was complicated and wasteful of material in the case of laminates having a large number of plies. Another procedure was to use a dado blade to cut ¼-inch deep grooves in alternate plies of a 2-inch section (Fig. 8-B). The procedure finally adopted, which greatly simplified specimen preparation, was to saw ¼-inch deep kerfs adjacent to each glue line (Fig. 8-C). For specimens prepared in this manner, the testing tool was provided with anvil faces having a narrow, 3/16-inch high vertical extension or bite that fits into the kerf cuts to hold, but not split, the specimen (Figs. 9 and 10).

Performance of Experimental Adhesives in Laminates: The tensile shear strength of parallel-grain bonded wood is often five to ten times as great as the strength of crossband veneer assemblies of the same wood. The implication here is that since the wood is strongest in the grain direction, the adhesive must also be able to match or exceed wood strength.

The adhesive containing equivalent quantities of HT-120 and RL resin in a water-methanol solvent was used to prepare two-ply boards from fir and hard maple stock. The results presented in Table 4 also give comparable data for a commercial resin (R1) used as recommended by the manufacturer. The cold, and boiling water cycles are the same as used in testing exterior fir plywood (1). It is evident from these results that the HT-120 formulation yields bonding strength in excess of that required by military specifications (8, 9). This adhesive was also used to prepare two 36-inch long, 8-ply laminates from edge-grain fir for weathering tests. Results of these tests are given in Table 4.

The notable disadvantage of the above adhesive formulation is that methanol is highly volatile and evaporates rapidly. Open assembly time is limited to about 5 minutes. Furthermore, methanol is a poor solvent for HT-120 and adhesive spreading characteristics are poor. In spite of these disadvantages, it is felt that this formulation could be adapted for use in automated lamination of standard dimension structural timbers.

Considerable effort was spent trying to improve glue-spreading characteristics and open assembly time tolerance so that adhesive working properties would meet the requirements of industry. The adhesive containing equal quantities of HT-120 and synthetic resin was modified by the addition of various polar organic solvents and other reagents. Immediate improvements in spreading characteristics were obtained by adding

TABLE 3

HT-120 and Resorcinol-Formaldehyde Resin at 40% T. S. in 50/50 Water-Methanol

Liquid Adhesive Base			Glue[2] Mix	Exterior Plywood Tests[3]					
						Cyclic Tests[4]			
				Dry Bond[4]		Cold Water		Boiling Water	
Ratio HT-120/ Res.	Viscosity Poises at ---° F.	pH	Pot-life at 68°F. hrs.	Strength psi	% WF	Strength psi	% WF	Strength psi	% WF
.0	15.3	9.5	1.5	210	83	179	93	177	96
.[illegible]	2.1[1]	9.0	4.5	210	92	190	94	184	95
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[1] Low viscosity due to 56% T.S. content.

[illegible] g. adhesive base, 15 g. hardener.

[3] Six 1/4 inch 3-ply panels
.1 inch Douglas fir veneer: 8% moisture
Glue spread: 50 lb./Mgl
10-20 min. closed assembly time
Pressed 16 hrs. at 77° F. and 175 psi
Cured 5 days at 77° F. prior to tests.

[4] Average of [illegible] values.

Table 4

Initial Work with Parallel-grain Lamination

Adhesive Base: Solvent; % Total Solids Content; Viscosity, Poises at 77°F.; pH	Glue Mix Pot-life at 68°F. hrs.	Block Shear Tests on Laminates[3]: Cyclic Tests: Dry Bond: Strength psi	% WF	Cold Water: Strength psi	% WF	Boiling Water: Strength psi	% WF
R1 (as is comml. resorcinol)	5+[1]	Hard Maple, 2-ply[4]					
T.S. = 58.7%, V = 13.5 pH = 9.0		3250	50	1656	94	1538	79
1:1 HT-120-RL	4.5[5]	Hard Maple, 2-ply[4]					
50/50 water-methanol		2915	52	1736	100	1473	90
T.S. = 40%, V = 5.0		Douglas Fir, 2-ply[5]					
pH = 8.85		1414	99	1018	100	723	99
		[illegible] Fir, 8-ply laminate[6]					
Initial Test		1280	97				
6 months weathering		1180	[illegible]				

[1] [illegible] g. adhesive base, [illegible] g. hardener.

[2] 100 g. adhesive base, 15 g. hardener.

[3] Laminating conditions:
Wood: 8-10% moisture
Glue spread: 50 lb./Mgl
20 min. closed assembly time
Pressed 16 hrs. at 77° F.; Fir at 175 psi, Maple at 250 p
Cured 7 days at 75° F.

[4] Average of 10 values, each test.

[5] Average of 20 values, each test.

[6] Average of 56 bond test values.

TABLE 5

1:1 HT-120:RL Resin: Effect of Solids Level and Variables in Solvent Medium on Adhesive Working and Bonding Properties

Liquid Adhesive Base[1]			Glue Mix[2]				Assembly Time at 75°F.	2-ply Laminate[3]	
T.S. %	Solvent Medium: W = water + 1% high visc. CMC; M = methanol, E = ethanol, P = n-propanol, G = Ethylene glycol	pH	Pot-life at 68°F. hrs.	Initial Viscosity Poises at 77° F.	Spreading Characteristics	Glue Spread lb./Msgl.	open/ closed min.	Dry Bond Test[4] Strength psi	% WF
40	50/50 W/M	9.4	4.0	10.2	poor	50	0/20	1614	99
	75/25 W/M	9.1	1.0	118.0	good	50	10/20	dry glue line	
	50/50 W/P	9.4	2.0	4.3	fair	50	0/20	no test	
	50/40/10 W/E/G	9.4	3.0	7.3	fair	50	5/20	1266	88
	50/30/20	9.2	2.5	11.6	good	50	10/20	1312	92
	50/30/20 W/P/G	9.2	2.0	11.5	good	50	10/20	1212	80
30	70/30 W/M	9.4	2.0	25.2	good	65	10/20	1483	84
	75/25 W/M	9.3	1.5	90.0	good	65	5/20	1519	96
	40/40/10 W/E/G	9.4	1.5	7.7	fair	50	5/20	1288	87
	55/35/10 W/E/G	9.2	3.5	2.25	good	50	5/20	1459	100
	80/20 W/G	8.7	0.6	17.7	very good	65	20/0	1488	88
	70/30 W/G	8.4	2.0	24.4	very good	65	20/0	1699	92
25	55/35/10 W/E/G	9.1	3.5	2.7	good	65	5/20	1615	91

[1] Proportions in % by weight.

[2] 100 g. adhesive base +
15 g. hardener for 40% T.S.
12 g. hardener for 30% T.S.

[3] Edge-grain Douglas fir, 8-12% moisture.
Pressed 16 hrs. at 75° F., 175 psi
Cured 7 days at 75° F.

[4] Average of 10 block-shear values.

[5] Total solids: 30%

TABLE 6

1:1 HT-120:RP1 Resin: Effect of Solids Level and Variables in Solvent Medium on Adhesive Working and Bonding Properties

Liquid Adhesive Base			Glue Mix[2]			Assembly Time at 75°F.	2-ply Laminate[3]	
T.S. %	Solvent Medium:[4] W = water + 1% high visc. CMC; M = Methanol, E = Ethanol, D = Dimethyl formamide, G = Ethylene glycol, A = Acetone	pH	Pot-life at 68°F. hrs.	Initial Viscosity, Poises at 77° F.	Spreading Characteristics	open/ closed min.	Dry Bond[4] Strength, psi	Cold Water Cyc.
40	70/30 W/E	9.5	1.75	66.0	good	10/10	1800-87	
	70/30 W/D	9.5	2.0	120.0	good	12/15	1796-93	
	70/30 W/G	9.1	2.0	41.0	very good	20/0	1711-86	58
	70/30 W/G(no CMC)	9.6	0.5	150.0	fair	---	no test ---	
30	100 W	9.2	2.0	71.0	good	20/0	1434-59	
	60/30/10 W/E/G	9.4	2.5	8.7	very good	10/10	1854-89	
	70/10/20 W/E/G	9.5	2.5	77.0	very good	15/5	1592-84	74
	70/30 W/G	9.6	1.25	13.0	very good	20/0	1678-95	46
	80/20 W/G	9.6	0.8	36.2	very good	20/0	1594-81	35
	60/30/10 W/G/A	9.7	1.5	56.0	very good	20/0	1453-98	79
	70/20/10 W/G/A	9.7	1.25	43.0	very good	20/0	1478-98	90
	70/20/10 W/G/M	9.6	1.25	9.8	very good	20/0	1541-82	75
	60/20/20 W/G/M	9.5	1.75	4.6	very good	20/0	1575-98	
	50/20/30 W/G/M	9.6	3.0	25.0	very good	20/0	1403-95	
	20/30/50 W/G/M	10.0	7+	0.9	poor	5/15	1818-95	7

[1] Proportions in % by weight.

[2] 100 g. adhesive base +
15 g. hardener for 40% T.S.
12 g. hardener for 30% T.S.

[3] Same as previous table
Glue spread: 65 lb./Msgl.

[4] Average of 10 block-shear values.

small amounts of high viscosity water-soluble organic colloids such as carboxymethylcellulose (CMC). This particular additive also acted as a buffer to stabilize pH. It was theorized that CMC, by its protective colloidal film action, might reduce the rate of solvent evaporation and solvent loss by penetration into the wood so that open assembly properties would be improved. Solvents having higher boiling points than methanol and better dissolving power for HT-120 were tested.

In the experiments summarized in Table 5, adhesive solids level was varied from 25 to 40 percent. At all solids levels, the greatest improvement in working properties resulted from the use of 10 to 20 percent ethylene glycol in the solvent medium. Eliminating methanol or ethanol resulted in very short pot-life. Even at 25 percent T.S., the adhesive was found capable of yielding excellent bond quality in Douglas-fir.

The performance of HT-120 in combination with a less expensive phenol-modified resorcinol-formaldehyde resin and using various solvents is shown in Table 6. Formulation at 40 percent total solids was abandoned at this point in favor of the 30 percent level. Again, whenever methanol solvent was reduced or eliminated, pot-life became quite short. In this work, maximum open-assembly time was fixed at 20 minutes. The effect of eliminating CMC is also illustrated in experiments 3 and 4 of this series. In this case, pot-life reduction is considered to be largely due to high pH.

The relationship between pot-life and adhesive pH was studied extensively. Reduction in the amount of sodium hydroxide used to dissolve the HT-120 resulted in poor bonding quality without, in many instances, any benefit to pot-life. Addition of mineral acids to reduce pH likewise did not contribute to better pot-life. The use of organic acids, and particularly fairly weak acids that are also capable of forming complexes, as a means of reducing pH usually resulted in the solution of pot-life difficulties, as illustrated by the results given in Table 7. Maleic acid, added as the anhydride, was found to be very effective for pH control so as to provide pot-life ranging from 2.5 to 6 hours. A solvent medium that seemed to provide the best balance of adhesive properties contained 60 percent of 1 percent aqueous CMC, 30 percent ethylene glycol and 10 percent acetone.

This solvent medium and pH control with maleic anhydride was tested in HT-120 formulations using a number of commercial resins, as shown in Table 8. In all except one case, the addition of maleic anhydride not only extended pot-life but also improved bonding quality.

TABLE 7

1:1 HT-120:RP1 Resin: Effect of pH on Pot-life and Adhesive Working and Bonding Properties

30% T.S. Liquid Adhesive Base			Glue Mix[1]		2-ply Laminate[2]	
Neutralizing Agent - % of HT-120 wgt.	Solvent Medium; Proportions in % by wgt. W = water + 1% high visc. CMC, G = Ethylene glycol, A = Acetone, M = Methanol	pH	Pot-life at 68°F. hrs.	Viscosity Poises at 77° F.	Dry Bond[3] Strength, psi	Cold Water Cycle - % WF
None	70/30 W/G	9.7	1.25	12.9	1678-95	44-81
None, HCl, 2.4	" "	4.1	1.25	25.6	1570-83	51-81
Acetic acid, 5.7	" "	5.0	1.25	40.2	1418-80	-
None	60/30/10 W/G/A	9.7	1.5	56.0	1453-98	76-87
Acetic acid, 5.2	" "	5.7	3.0	27.2	1276-89	67-79
Citric acid, 10	" "	4.1	2.5	34.0	1388-93	74-85
Maleic (10	" "	4.8	5.5	10.7	1506-100	76-85
Anhydride (5.4	" "	5.4	2.5	52.5	1568-86	41-82
Oxalic acid, 10	" "	1.8	7.5	18.6	1415-89	70-89
Phthalic anh., 10	" "	4.2	5.4	17.7	1417-93	64-89
None	50/20/30 W/G/M	9.6	3.0	25.0	1403-95	81-87
Maleic anh., 5.7	" "	4.5	4.5	11.4	1281-93	69-89

[1] 100 g. adhesive base, 15 g. hardener
All adhesives had very good spreading characteristics.

Glue spread: 65 lb./Msgl.
Assembly time: 20 min. open at 75° F.
5 min. closed
Other conditions as previously indicated.

[2] Average of 10 block-shear values.

TABLE 8

Commercial Resorcinol or Resorcinol-Phenol-Formaldehyde Resins and HT-120 at 1:1 Ratio

30% T.S. Liquid Adhesive Base - Solvent: 60/30/10, 1% Aqueous CMC/ Ethylene Glycol/Acetone			Glue Mix[1]		2-ply Laminate[2]			
			Pot-life	Viscosity	Dry Bond[3]		Cold Water Cy	
Resin	Maleic Anh. 10% of HT-120	pH	at 68°F. hrs.	Poises at 77° F.	Strength psi	% WF	Strength psi	% W
RL	-	8.8	2.0	7.0	1488	89	865	
RL	+	8.1	4.0	4.0	1256	95	644	
R1	-	9.0	2.5	8.9	1486	85	335	
R1	+	8.0	7.0	6.7	1444	88	589	
R2	-	9.2	1.5	6.9	1655	87	842	
R2	+	8.3	4.0	4.6	1496	98	650	
R3	-	9.4	1.5	10.2	1560	95	670	
R3	+	9.7	4.0	4.8	1175	93	611	
RP1	-	9.4	2.0	7.4	1506	100	791	
RP1	+	8.8	5.5	10.7	1506	100	791	
RP2	-	9.2	1.5	9.72	1744	80	865	
RP2	+	8.1	3.5	9.8	1550	95	697	
RP3	-	9.4	2.0	8.4	1437	85	587	
RP3	+	8.4	5.0	35.9	1416	83	537	

[1] 100 g. adhesive base, 12 g. hardener
All adhesives had good spreading characteristic

Glue spread: 65 lb./M.g.
Assembly time:
20 min. open at 75°
5 min. closed
Other conditions, pr[illegible]

[2] Average of 10 block-shear values.

Figure 9.—BLOCK-SHEAR TESTS were made in a universal testing machine at a head speed of 0.05 inch per minute.

The cold water cyclic test given in the tables corresponds to that used in testing exterior-type plywood (1), and involved three cycles of soaking in cold water for 16 hours with 8 hours drying at 140°F. in between, except that the first soaking treatment was for 48 hours. It was felt that this test was not drastic enough to simulate long-term weathering. Therefore, a test applied to block-shear specimens was devised that involved two cycles each of alternating 2-hour periods of soaking under vacuum at 25 inches Hg and pressure at 80 psi followed by 16 hours (overnight) of boiling. Specimens were broken while wet, but wood failure was read on dry pieces, as is general practice.

Application of this test in comparison with the normal dry-bond tests and cold-water soaking tests is illustrated in Table 9. In this series of experiments, the main objective was to study open-assembly tolerance. Ratio of HT-120 to synthetic resin and glue spread were also varied. As might be expected, the amount of HT-120 that can be tolerated in formulations with RP resins is more limited than in the case of straight resorcinols. Reducing HT-120 usage

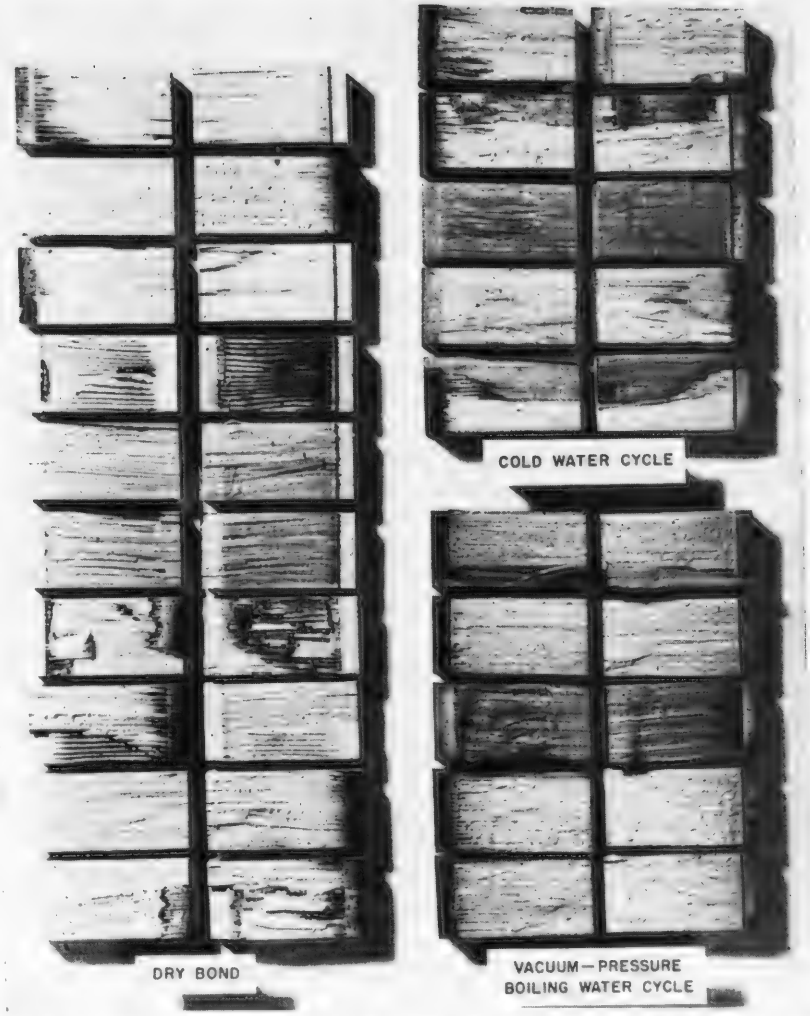


Figure 11.—TEST RESULTS where HT-120:RP2 ratio was 1:1.5, glue spread 85 lb./Msgl, and open assembly time was 100 minutes at 75° F.

Figure 10.—ANVIL FACES on test tool fit into kerf to hold specimen.

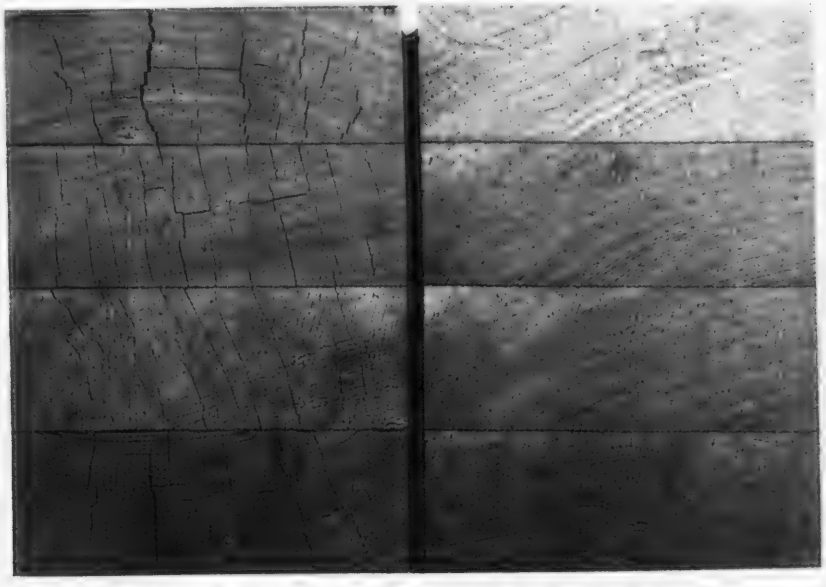


Figure 12.—VACUUM-PRESSURE cyclic test results in severe checking (left); specimens reconditioned for 2 years (right).

from 50 to 33.3 percent of the solids composition resulted in open-assembly tolerances as long as 100 minutes at 75°F., when using a glue spread of 85 lb./Msgl. Bonding quality was excellent in all tests. With straight resorcinols, adequate bonding quality was obtained even at 66.6 percent HT-120 usage. At this level, however, open-assembly tolerance was reduced to 60 minutes. It is generally understood that open-assembly time can also be extended by going to lower assembly temperatures, such as 60°F., instead of 75°F. Under such conditions, at ratios of 1:2 of HT-120:RP2 resin, using the formulations of Table 9, it was possible to extend open-assembly time to 2 hours without affecting bonding quality. The appearance of broken test specimens in an experiment where HT-120:RP2 ratio was 1:1.5, glue spread was 85 lb./Msgl and open assembly time was 100 minutes at 75°F. is shown in Figure 11.

Preparation of small laminated timbers, under conditions approximating as nearly as possible those encountered in industry, was the final means used to evaluate experimental adhesives prior to actual field testing. The results presented in Table 10 are believed to fulfill all of the current industrial requirements for adhesives to be used for weatherproof Douglas-fir laminates. It was of interest in the first three experiments of this series to determine the strength of the wood represented in each lamina along with glue-bond strength. Values listed in parenthesis are for average wood strength and were, in general, somewhat higher than for strength determined at the glue line. Estimation of the amount of delamination at the glue line during the vacuum-pressure cyclic test is rendered somewhat difficult when extensive wood failure occurs in these zones of high stress. This test results in severe checking of the wood, as shown in Figure 12. Although the wood eventually recovers more or less its original appearance, as indicated in the block on the right of Figure 12, which was conditioned in the laboratory atmosphere for two weeks, the wood is considerably weakened. In order to check strength and wood failure at the glue line, blocks were cut into shear specimens and broken dry. The results in the two columns at the right of Table 10 indicate passable wood failure levels, but average strength is drastically diminished over original dry strength.

Finally, it is noted in Table 10 that open assembly could be extended to as long as 70 minutes at 67°F. The HT-120:RP resin adhesives at 1:1.5 and 1:2 ratio when used at 60°F. withstood 120 minutes open assembly, yielding results comparable to those given in the table.

Economic Considerations

The production of bark extracts such as HT-120 is feasible and economic on a sufficiently large scale, for example, on the order of 10,000,000 pounds per year. Substantial markets would have to be developed to utilize single plant outputs of this size, and in order to warrant construction of such production facilities. Assuming a retail value per pound of: 12.5¢ for HT-120, 78¢ for technical-grade resorcinol, 70¢ for 60 percent T.S. straight resorcinol resin adhesives, and 45¢ for 56 percent T.S. phenol-modified resorcinol adhesives, it is simple arithmetic to calculate the advantages of using HT-120. On a glue-line basis, there are even greater savings, since the formulations containing HT-120 are applied at 30 percent solids instead of 56 to 60 percent. An attempt to dilute commercial resins to this level did not yield satisfactory results.

Conclusions

It has been demonstrated that a unique, highly-reactive extract obtained from western hemlock bark can be used in the formulation of cold-setting waterproof adhesives for Douglas-fir. It is possible to modify or tailor-make adhesives of this type to fit the operational requirements of industry. Utilization of this natural, forest-grown resource permits a reduction in adhesive costs and at the same time contributes to the upgrading of our basic forest resource—wood.

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[illegible] HT-120:Resin Ratio on Open Assembly Tolerance

Resin	Base[1] Ratio 1-120: Resin	pH	Glue Mix[2] Pot-life at 68°F. hrs.	Viscosity Poises at 77° F.	2 ply Douglas Fir Laminate Glue Spread lb./Msgl	Open Assembly Time min. at 75° F.	Dry Bond[4] Strength	Cold[5] Water Cycle	Vacuum-Pressure Boiling W. Cycle
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	65	15	1526-89	699-84	799-87
					"	[illegible]	[illegible]	[illegible]	[illegible]
					"	45	1517-87	654-79	809-77
					"	75	1275-83	574-84	792-68
					85	60	1507-90	209-84	675-74
					100	100	1514-83	391-87	646-68
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1188-90	546-100	735-82
							1087-89	603-99	662-96
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
							[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
R1	1:1	8.7	4.0	9.8	65	40	1189-85	780-78	840-78
R2	2:1				65	20	1041-84	729-96	751-78

[illegible] total solids, solvent [illegible] 60/30/10, [illegible] except 10% in exp[illegible]on tot[illegible]

[illegible] g. adhesive base, 15 g. hardener.

[illegible]

[4] Average of 10 block-shear values.

[illegible] Average of 5 block-shear values.

TABLE 3

[illegible] ply Laminated Timbers Using 2 x 6 inch Douglas Fir Lumber

Ratio HT-120: Resin	Resin	Glue Spread lb./ Msgl	Assembly Time, Temp. Min. °F.	Dry Strength Bond[1] (Wood)[2] psi	% WF	Vacuum-Pressure Cycle + 16 hrs. Boiling Water Strength[3] psi	% WF	Vacuum-Pressure [illegible] -Drying Cyc Delamination[3] %	Strength[3] psi	% WF
1:1	R1	65	12 78	1206 (1345)	92	707 (812)	85	6	648	
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
			30 78	1030 (1331)	92	704 (786)	91	5	913	
1:1	R2	65	20 78	1023 (1110)	92	678 (696)	87	1	829	
			30 78	1265 (1285)	94	751 (799)	91	0	999	
1:1	RP2	65	10 78	1257 (1384)	96	801 (812)	81	5	792	
			15 78	1257 (1311)	86	787 ([illegible])	88	5	692	
1:1.5	RP2	65	50 75	1262	90	747	92	7	827	
		85	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1:2	RP2	65	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
		85	70 70	1422	93	842	91	0	1259	
1:1	RL	65	50 67	1414	96	907	96	0	1139	
		85	70 67	1475	95	845	91	0	1218	

All adhesive contained [illegible]
Solvent = 60/30/10 W/G/A
Glue mix: 100 g. adhesive base,
12 g. hardener

[illegible] Average [illegible] 2 b[illegible] values.

[2] Strength of adjacent wood, average of [illegible] values.

[3] Average of two va[illegible]

Hydrogen Bonding and Swelling of Wood

IN THE DIOXANE-WATER SYSTEM[1, 2]

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External swelling of wood in the dioxane-water system has maximum value at 0.8 mole fraction water. Relationship of swelling to total pressure and to molal dielectric polarization appears to be linear.

THE DIMENSIONAL INSTABILITY of wood resulting from changes in moisture content is a serious problem associated with the structural use of wood. The studies of Stamm and his colleagues (15) will serve as an exemplar of the research which has been directed to the solution of this problem and which will undoubtedly be projected into research yet to be conducted on the dimensional stabilization of wood. Much is known about the conditions under which wood will shrink or swell, but there is little agreement in definition of factors that control the dimensional changes.

Stamm (14) appears to have been the first to recognize the possible relationship between hydrogen bonding and swelling of wood and Nayer (11), as a result of a study initiated in Stamm's laboratory, has suggested as a working hypothesis that ". . . the degree of swelling bears a direct relationship to the intensity of hydrogen bonding between the constituents of wood and the swelling agent and that steric hindrance is a controlling influence on the intensity of hydrogen bonding."

In an earlier report (10) Nayer described among other things, the swelling behavior of wood in dioxane-water mixtures and concluded that the addition of small amounts of water to dioxane caused a greater volumetric swelling of the wood than did either water or dioxane alone. A similar phenomenon was reported to occur for pyridine-, morpholine-, and piperidine-water systems. No explanation was offered for these unexpected observations.

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The objectives of the present work have been to determine the external volumetric swelling of maple wood in the dioxane-water system and to consider its relationship with the physical properties of the system.

Experimental

The material for this study was taken from a carefully air-dried plank of hard maple sapwood, *Acer saccharum*, Marsh, selected in a green condition on the basis of its freedom from defect, straightness of grain, and uniformity of growth ring configuration. The moisture content of the seasoned plank was 6–7 percent; the average specific gravity based on dry volume was 0.69, and the average ring count was 13 per inch.

Square cross sectional specimens 33 by 33 by 4 mm were cut with a fine-tooth, hollow-ground saw to give a smooth true surface. A longitudinal dimension of 4 mm was chosen to allow complete and rapid penetration of the swelling agent without significant distortion of the specimen during swelling. The other dimensions were carefully oriented to give true radial and tangential representation.

Sampling Procedure: A random selection of 1040 sections was randomly divided among 4 large containers. Thirteen samples of 80 specimens were randomly selected from these containers, and the samples were further subdivided into groups of 10 specimens, each of which was assigned a number for identification. Groups were then randomly selected as needed to complete the experimental plan.

Measurement of Samples: Tangential and radial measurements of the specimens were made with a dial gauge micrometer. A radial dimension, for example, represented the average of three measurements taken at the ends and center of the tangential edge of a specimen in a direction perpendicular to the annual rings. The range of each measurement, as determined from measurement and remeasurement of samples of 10 at different times, was found to be 0.001 inch with a maximum deviation from the mean of 0.0005 inch.

Preparation of Dioxane-water Solutions: Reagent grade 1,4-dioxane was allowed to stand 1 week in bottles containing sodium hydroxide pellets. One-liter portions of the material were then decanted into a 2-liter, round-

What This Research Means

Much is known of the conditions under which wood will shrink or swell, but there is disagreement in the explanations of *why* wood swells. These data illustrate a similarity of the curve representing the swelling of maple wood in the dioxane-water system with curves representing some of the thermo-dynamic properties of the system under the same conditions. A mechanism, controlled by hydrogen bonding, is offered in explanation of the wood-swelling properties of this and similar binary liquid systems.

This research will have different meanings to different readers: Some may question, others may accept, and still others may find a challenge in pursuing the concept of hydrogen bonding as a controlling factor in the swelling behavior of wood. The net effect will, in any event, be some measure of better understanding of the chemical and physical properties of wood.

[1] Univ. of Minn. Agri. Exper. Stat. Sci. Jour. Ser. No. 1285, based on a thesis of J. C. Oberg presented to fulfill requirements of master of science.

[2] Contributed to the Journal Dec. 1959; revised version received March 17, 1960

Table 1.—THE PERCENTAGE VOLUMETRIC SWELLING OF MAPLE SECTIONS FOR EACH OF THE 13 SOLUTIONS AS MEASURED AT SPECIFIED TIME INTERVALS

SOLUTION		TIME										
Mole Water	fraction H_2O	1 hr.	2 hr.	3 hr.	4 hr.	8 hr.	24 hr.	48 hr.	5 days	10 days	20 days	30 days	60 days
1.	1.0	15.80	16.16	**16.47***	16.39	16.40							
2.	0.95	**17.20***	17.29	17.69	17.69	17.36							
3.	0.90	**18.05***	18.39	17.87	18.37	18.56							
4.	0.85	**18.68***	19.21	18.83	19.13	18.88	19.18	18.82					
5.	0.80	**18.83***	18.89	19.24	19.19	19.10	19.19	19.20					
6.	0.60	**18.80***	19.34	19.27	19.40	19.41	19.34						
7.	0.40	17.98	**18.51***	18.35	18.64	18.88	18.93						
8.	0.30	15.95	..	17.99	..	**18.43***	18.77	18.72	18.69				
9.	0.25	10.53		17.42		17.64	**18.05***	18.14	17.96				
10.	0.20	.....	13.92	..	16.82	.	**17.48***	17.73	17.42	17.82			
11.	0.15	.....	5.35		11.99	.....	**16.11***	16.62	16.64				
12.	0.1		.		.	10.95	14.28	**15.43***	15.88	15.85			
13.	0.0	.			..	..	5.42	7.74	11.47	12.73	13.04	**13.72***	14.22

*Denotes point of equilibrium swelling.

bottomed flask equipped with a reflux condenser through a standard taper ground joint and arranged for heating with an electric mantle. Freshly cut metallic sodium was added in small quantities to the flask, and the system was kept at reflux temperature until the sodium finally remained as clean molten globules. The purified dioxane was distilled from the residue over a boiling point range of 1.5° C. Stock solutions of dioxane in water were then prepared in accordance with the schedule of concentrations given in Table 1. The refractive indices of the solutions as interpolated from the data of Hovorka (6) were used as a means of accurately adjusting the solutions to the specified concentrations. Freshly distilled water was used in all cases.

Typical Experimental Procedure: A swelling system is defined as an 8 ounce wide mouth glass jar containing 10 "oven dry" wood sections submerged in 125 ml. of the appropriate dioxane-water solution and sealed with aluminum foil by means of a tightly screwed cap. "Oven dry" is defined for the purpose of this study as the condition of a specimen after subjecting it to a temperature of 60°–65° C. under a vacuum of 29 inches Hg for a period of 24 hours.

The procedure for evaluation of the swelling of wood in pure water (1.0 mole fraction water) is given below.[3] The experimental design required that five swelling systems be established for measurement at 1, 2, 3, 5, and 8 hours, respectively, as shown in Table 1. Five groups of ten specimens were "oven dried" and placed immediately in a dessicator over $CaCl_2$ to cool for a period of 15 minutes. Each specimen was measured as quickly as possible and returned to the dessicator, after which the sample was returned to the oven for a period of 30 minutes. After again cooling in the dessicator, each group of ten was sealed at room temperature (approximately 25° C.) in its assigned jar containing its aliquot of swelling agent. After the specified time, a system was opened, the swollen sections were measured and discarded, and the refractive index of the solution was redetermined. In no case did the refractive index of the solution change more than + 0.001.

External Volumetric Swelling: The percentage of volumetric swelling of a system is defined for this study as the change in area, after swelling, of a group of ten specimens expressed as percent of the original "oven dry" area. The area is defined as the product of the average radial and average tangential dimension of the ten specimens which constitute a group.

Although the extent of swelling is represented as based on a net change in volume, it is in fact determined as a net change in area. It can be shown, however, that the change in the longitudinal dimension on swelling is negligible for the purpose of this simplification.

Statistical Technique: The data resulting from these experiments are given in Table 1. Both the magnitude of the percent volumetric swelling at equilibrium and the time required to reach an equilibrium value for a given concentration was defined as that pertaining to the system for which the last significant difference occurred ("t" test) at the 5 percent level.

An analysis of variance for the equilibrium swelling points at the different concentrations showed a highly significant difference.

Discussion of Results

It is apparent from Fig. 1 that the maximum percent volumetric swelling (SW/MF Curve) occurs at a concentration of about 0.8 mole fraction water. A comparison of Fig. 1 with Fig. 2 shows a striking similarity in the general form of the curves representing the percent volumetric swelling of wood and the total vapor pressure (6) of the dioxane-water system throughout the range of concentrations. This similarity extends to the curve of Fig. 3 representing the molal dielectric polarization (1), and suggests the possibility of a relationship between the total pressure, or the dielectric polarization, and the ability of the system to cause swelling of wood. Figures 2 and 3 also illustrate near linear trends in the relationships between vapor pressure and swelling (VP/SW Curve), and polarization and swelling (P/SW Curve) for systems containing either large amount of water (0.8–1.0 mole fraction) or large amounts of dioxane (0.7–1.0 mole fraction). The portion of the respective curves lying between the two regions of linear trend may be interpreted as representing a transition from the predominant influence of one property of the system to the influence of a different property on its swelling power. That these two properties are, in fact, different is supported in Fig. 4 by the observation that the rate of swelling of wood (T/A Curve) is much greater in the system of high water concentration than in the system of low water concentration. The equilibrium value for the percent volumetric swelling may, however, be identical under the predominating influence of either property. The derivation of this suggested difference may be further visualized from consideration of the data in Table 1. For example, equilibrium values of 17.20 and 17.48 percent volumetric swelling were obtained at the

[3] The mole fraction water, x, is determined from the formula:

$$x = \frac{\frac{\text{gm water}}{18}}{\frac{\text{gm dioxane}}{88} + \frac{\text{gm water}}{18}} = \frac{\text{moles water}}{\text{moles dioxane} + \text{moles water}}$$

and is used in this work as a common basis of comparison of the swelling properties of the water-dioxane system with other properties of the system with respect to concentrations of the components.

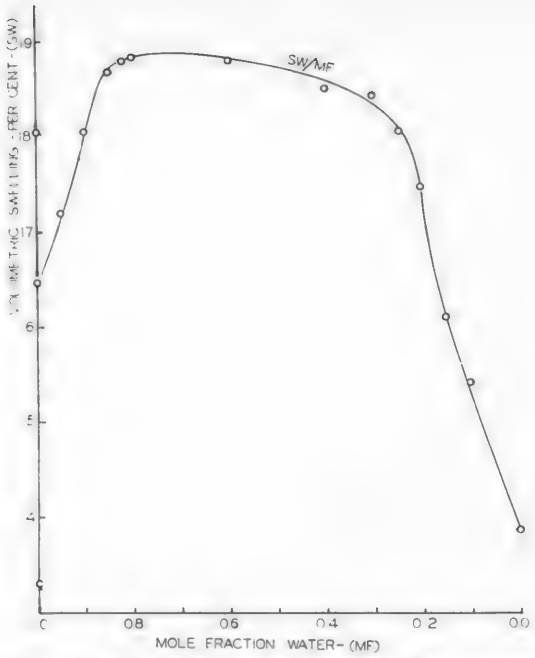

Fig. 1.—The swelling of maple wood in the dioxane-water system at 25°C.

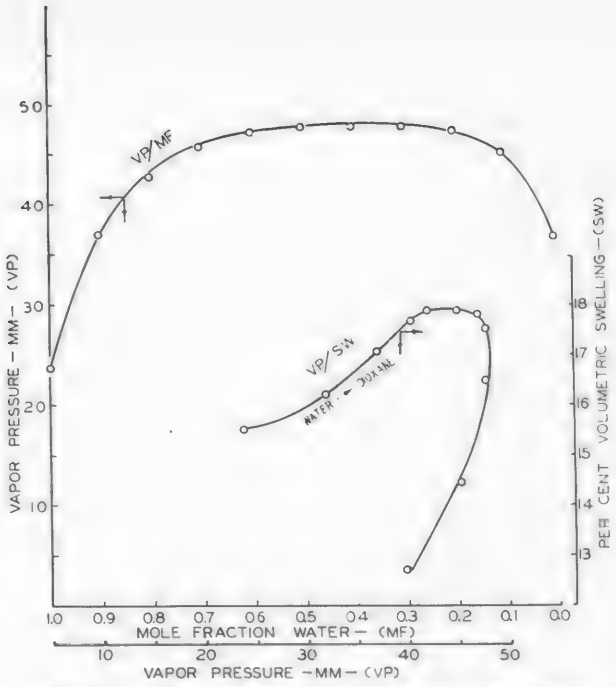

Fig. 2.—The swelling of maple wood in relation to the vapor pressure of the dioxane-water system at 25°C.

respective concentrations of 0.95 and 0.20 mole fraction water. The time necessary to attain these equilibrium values was 1 hour and 24 hours respectively. This difference in rate of establishment of equilibrium is offered as support for the inference that the properties of these two systems which control the swelling of wood are in fact different, although the net effects on the equilibrium swelling values may be identical.

In order to develop a reasonable explanation of these observed phenomena, it will be appropriate to consider in more detail some of the physical properties of this system which agree in abnormality with the swelling property. Hovorka (6) reports that the partial pressure and the partial molal volume of water are at a point of greatest abnormality and that the minimum freezing point occurs at a concentration of about 0.8 mole fraction water. Geddes (3) reports that at about 0.8 mole fraction water the fluidity curve for the system shows the maximum deviation from linearity and calculates that at this point about 5 percent of the system exists in association as the hydrate containing 5 moles of water ($C_4H_8O_2 \cdot 5H_2O$). Gordy (5) has obtained data from a study of infrared spectra which support his suggestion that an associated complex, based on hydrogen bonding of water and dioxane molecules, appears in the region of 0.8 mole fraction of water. Gordy has also concluded in an earlier report (4) that water appears to exist primarily as an associated dimer when at low concentration in dioxane. It appears to be generally accepted (2) that water in the pure liquid state exists to some degree as a polymer represented as $(H_2O)x$.

The authors suggest, within the scope of the above discussion, that since hydrogen bonding relationships have been proposed as a means of explaining abnormalities in vapor pressure of the dioxane-water system (8), hydrogen bonding as proposed by Nayer (11) may also be acceptable in explanation of the abnormalities in swelling behavior of wood in this system. It is further suggested that the swelling property of this system with respect to wood might be properly considered an "intensive" thermodynamic property of the system (9) subject to the influence of hydrogen bonding in the same manner as the vapor pressure and molar dielectric polarization.

It may then be postulated that the linear relationship between the volumetric swelling of wood and the molar dielectric polarization of the system in the range of concentration from 0.8 to 1.0 mole fraction water is the result of a linear influence of the system's associational hydrogen bonding on each of the two correlated intensive physical properties. With the acceptance of this postulation, it becomes possible to describe a reasonable mechanism of swelling for this system: The magnitude of external volumetric swelling of wood in pure water is limited by the extent to which liquid water in its highly polymerized state is able to associate through hydrogen bonding with wood substance. The limiting factors in this condition could well be stearic hindrance and the possibility that the bonding energy between water molecules is greater than that between water molecules and wood substance. As dioxane is added to the system, the degree of association between water molecules is reduced, and a new species of less highly polymerized water either alone or in association with dioxane may assume increasing control of the system while both the rate and magnitude of volumetric swelling increase to a maximum. Both increases may be related to a decrease in stearic hindrance as a result of depolymerization of the water and to an increase in the hydrogen bonding affinity between wood substance and the new species of molecular association. The subsequent decline in both rate and magnitude of swelling with increasing concentration of dioxane in the system may be attributed to a dilution effect with respect to the water dimer until the degree of swelling is finally that characteristic of the pure dioxane.

It is of interest at this point in the discussion to refer to the swelling of wood in the acetone-water system as reported by Stamm (12). This system is comparable to the present system in that the effect of the addition of small

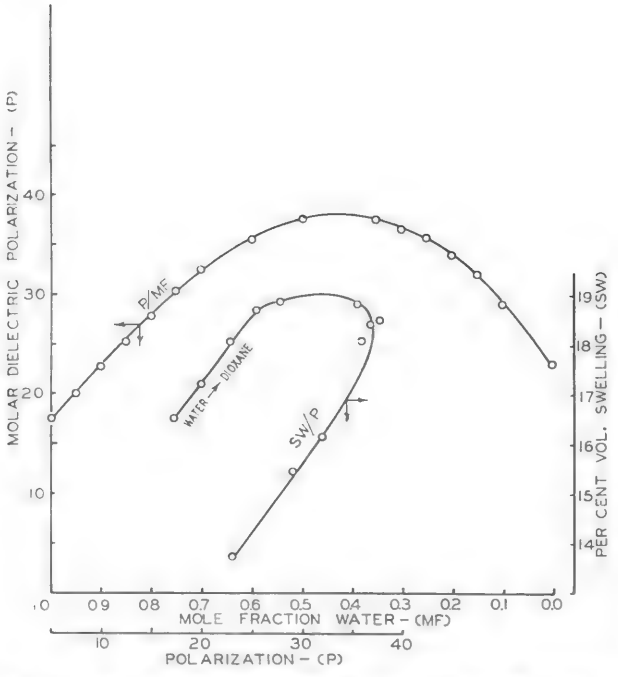

Fig. 3.—The swelling of maple wood in relation to the molal dielectric polarization of the dioxane-water system at 25°C.

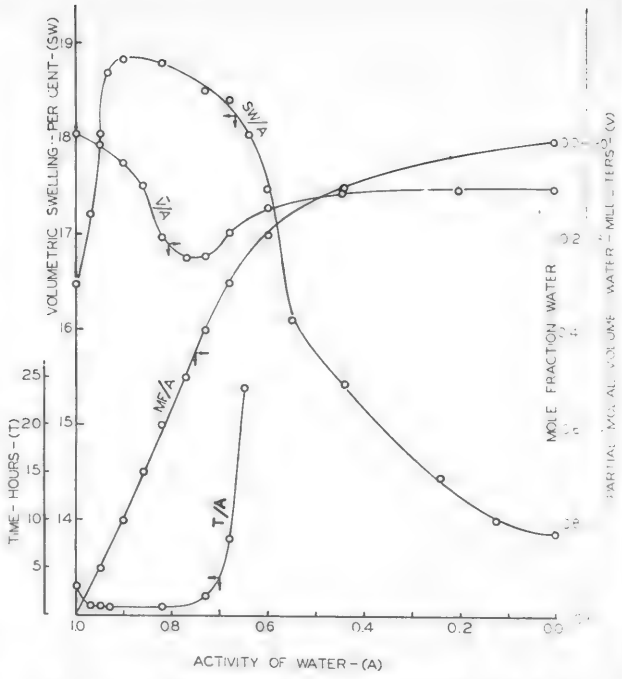

Fig. 4.—The relationship of volumetric swelling (SW/A curve), time to attain equilibrium swelling (T/A curve), and the partial molal volume of water (V/A curve) to the activity of water in the dioxane-water system at 25°C. The activity of water (A) represents the ratio of the partial pressure of water in the dioxane system to the corresponding vapor pressure of prue water. Assuming that pure water vapor behaves as an ideal gas, the activity of the water represents the effective concentration of water in the system.

amounts of acetone to water is such as to give a value of external volumetric swelling of wood which is greater than that of either water or acetone alone. The maximum swelling of wood is interpolated from Stamm's data to occur at about 0.74 mole fraction of water. A corresponding abnormality in the partial pressure of water in this system has been reported to occur in the same range of concentration as that for maximum swelling (7). Williams (13) has studied the infrared spectrum of this system and concluded that an associated complex exists between acetone and water which increases in intensity in a range of water concentration up to about 0.75 mole fraction. It may be suggested then that the mechanism proposed for the swelling of wood in the water-dioxane system is also applicable to that in the acetone-water system. It may also be appropriate to predict that this mechanism will apply to the swelling behavior of wood in the pyridine-, morpholine-, and piperidine-water (10) and other similar binary systems.

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Observe National Forest Products Week

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WORLD-WIDE
Forest Products News

PRODUCTION OF

Chemicals from Wood in Japan

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A summary of government, university, and industry activities and research on wood saccharification, hydrolysis, utilization of lignin, production of alcohol, fodder yeast, tall oil, furfural, and other products.

As a result of overcutting timber during World War II, forest rehabilitation became a major problem, and the Japanese Government decided on a policy of sound forest economy. To this end, the cabinet in 1955, adopted a 6-year plan that aims at establishing a sustained yield program for Japanese forests.

At the same time, the Ministry of International Trade and Industry agreed to support active and well-planned research in the field of wood chemistry and to recommend financing of projects that had reached pilot-plant stage. Appropriations made in this way were in addition to subsidies granted to the Japanese pulp and paper industries. They are listed in tables 1 and 2.

On April 1, 1955, the Council for Economic Timber Utilization was established as a part of the Economic Planning Agency. Headquarters of this council were with the Council for Forest Resources in order to insure and facilitate adequate communications. For investigations by this organization, the government appropriated 5 million yen ($14,000) in 1955, 6.5 million yen ($18,200) in 1956, and 3 million yen ($8,400) each in 1957 and 1958.

On January 27, 1958, the Council for Economic Timber Utilization decided to establish a special committee for wood chemistry.

Wood Saccharification and Related Problems

Bureau of Forestry, Ministry of Agriculture and Forestry. Soon after the war, the University of Tokyo and the Tokyo Institute of Technology started a joint project sponsored by the Special Forest Products Section of the Bureau of Forestry of the Ministry of Agriculture and Forestry. The pilot-plant work was carried out at the plant of Tsurumi Industrial Carbon Company in Yokohama City. In this plant, one ton of wood was hydrolyzed per day.

This project had to be suspended because of the unfavorable conditions immediately after the war. Unexpectedly, other people became interested in the commercialization of wood saccharification. Development work was resumed under the sponsorship of Hokkaido Forestry Development Institute and other private organizations.

The Council for Wood Saccharification. A relatively high percentage of the forests in Hokkaido consists of deciduous trees of poor quality. The local government wanted to use this stock as raw material for wood saccharification, and it assigned this project to the Hokkaido Development Institute. The majority of the research workers who cooperated in the project of the Bureau of Forestry also participated in this development.

In order to plan and coordinate research and development work on wood saccharification, the Council for Wood Saccharification of Hokkaido was established in 1951. The president of this council was the director of the Government Forest Experiment Station and the dean of the Tokyo Industrial University. Members of the research staffs of the Tokyo Education University, Tokyo University, the Chemical Engineering Department of Tokyo Institute of Technology, Department of Agricultural Chemistry of the agricultural faculty of Tohoku University, and the Yokohama Institute of Technology cooperated on the project. The

The Author: Kenjiro Takubo, a graduate of kyo University, has conducted research on zymes, adhesives, and terpenes. His division the Forest Experiment Station conducts re-rch on the chemistry of all forest products, luding pulp, paper, and fiberboard.

[1] Presented at Session VIII, Chemical Utilization, FPRS 14th Annual Meeting, June 7, 1960 in Montreal, Canada.

Table 1.—GRANTS TO APPLIED RESEARCH IN WOOD CHEMISTRY BY THE MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY

Year	Appropriation 1,000 Yen	Appropriation Dollars	Project	Recipient
1953	600	1,680	Utilization of waste wood and spent liquor	Tohoku Pulp Mill Company
1954	1,000	2,800	Manufacture of alcohol from sawdust	Fukuizumi Jyozo Kogyo Company
1955	900	2,520	Production of furfural from wood	Hokkaido Forestry Development Institute
1955	650	1,820	Production of furfural from some species of bamboo	Hokkaido Industrial Experiment Station
1956	2,700	7,560	Production of aromatic hydrocarbon by liquefaction of lignin	Noguchi Institute
1956	350	980	Air entraining agent, or: fluidization (?)	Arakawa Forest Chemicals Company
1957	2,300	6,440	Higher yield of furfural and oxymethylfurfural	Noguchi Institute
1958	2,300	6,440	Production of lignin gum and masterbatch from pulp mill spent liquor	Kokusaku Pulp Mill Company
1958	10,800	30,240	Wood saccharification by concentrated sulphuric acid process	Hokkaido Forestry Development Institute
1958	4,200	11,760	Simultaneous production of furfural and high grade cellulose from hardwood	Hodogaya Chemicals Company

research group, headed by Professor T. Kobayashi of the Tokyo Education University, made valuable contributions relative to reaction kinetics in concentrated sulphuric acid. Mr. T. Ito of the Wood Chemistry Division of the Government Forest Experiment Station contributed fundamental work in the field of prehydrolysis.

At first, the Council for Wood Saccharification aimed at the production of alcohol, other fermentation products, and fodder yeast. Consequently, efforts were directed for some time at the utilization of spent sulphuric acid in order to balance the economy of the process.

The objective of the project has been changed. It is now desired to obtain pure crystalline glucose as well as other sugars, such as pentoses, which can be obtained by prehydrolysis. In 1956, the Ministry of Agriculture and Forestry made a grant of 900,000 yen ($2,520) to the Hokkaido Forestry Development Institute. This grant was to be used for development of a continuous process for the production of furfural from pentose solutions. The Hokkaido Industrial Experiment Station received 650,000 yen ($1,820) for the exploration of production of furfural from pentose solutions obtained in the production of a bamboo fiber board. In 1954, the Ministry of Education granted 4 million yen ($11,200) to the agricultural faculty of the Tokyo Education University. With this grant, Professor Kobayashi and co-workers built a small-scale laboratory plant for batchwise wood hydrolysis. The capacity of this unit is about 220 pounds of sawdust per 8 hours.

This phase of the research revealed considerable detail of the fundamental reaction mechanism of each stage of wood saccharification.

In 1957, the Government of Hokkaido made a grant of 2,660,000 yen ($7,450) to the Council for Wood Saccharification specifying the following objectives:

1. Reaction of glucose with ammonia, including a few experiments on reactions during hydrolysis.

2. Research on deacidification of sugar solutions by ion-exchange resins.

3. Research on distillation of furfural.

4. Research on utilization of lignin.

In order to follow through, a pilot plant, "Hokkaido Wood Saccharification Pilot Plant," was built at the Hokkaido Forestry Development Institute in Asahigawa for 98.5 million yen ($275,800). Management of this plant was in the hands of the Hokkaido Government.

The pilot plant went on stream during the fiscal year of 1958. Its capacity was 2.5 tons per day of wood in the prehydrolysis step and 1 ton of wood per day in the main hydrolysis step. Machinery of the Sävö Process was used in the prehydrolysis step. Ten percent of the expense of this project was paid by the Ministry of International Trade and Industry.

Hokkaido Wood Chemical Company. The Hokkaido Wood Chemical Company was established in 1959 with a capital of 400 million yen. A plant is now under construction for the production of sugar by the concentrated sulphuric acid process. In its first stage, the new plant will have a capacity of 100 tons per day. The final goal is said to be 300 tons per day, making use of the low-quality hardwoods of Hokkaido.

Nippon Lignochemicals Company. This company is a subsidiary of a brewery. Its start was facilitated by two facts: (a) the sugar solution is readily usable and (b) byproduct gypsum can be sold profitably for the production of bean curds. In 1959, plant capacity was expanded to 5 tons of wood per day, using a batch system. Total capitalization was 100 million yen ($280,000). This company is the only manufacturer who can continue its integrated operation profitably and economically, although it is on a small scale.

The company uses its own prehydrolysis process based on the use of dilute acid and dilute alkali. They produce annually 420 tons of crystallized glucose, 400 tons of hydrol (expressed as 100 percent sugar), 2,000 tons of gypsum, and 50 tons of active charcoal. They plan to produce crystallized xylose in the future.

Hydrol is not bitter; it is sold at the same price as crystallized glucose as an additive to soy-bean sauce. Glucose is used in cake and other food stuffs. The byproduct lignin is processed to active charcoal for captive use by special fluid coking and fluidized activation.

This company is now planning to build a plant with a capacity of 50 tons of wood per day in the western part of Japan.

The process is shown on the following flow sheet.

Wood Hydrolysis Process

Sawdust

Alkali Pretreatment, Dil. Alkali

Acid Pretreatment, Dil. H_2SO_4

Centrifuge

Dryer

Blender, Conc. H_2SO_4

Ripening Tank

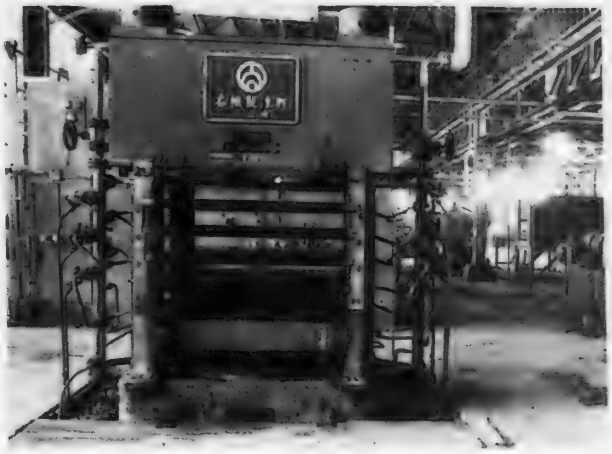
Hydrolyzer

Filter—Lignin—Active Charcoal

Table 2.—SUPPORT OF PILOT-PLANT PROJECTS BY THE MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY

Year	Appropriation 1,000 Yen	Appropriation Dollars	Project	Recipient
1954	8,000	22,400	Production of fodder yeast from spent liquor of sulphite pulp mill	Toyo Spinning Mill Company
1955	15,000	42,000	Wood saccharification and production of cellulose derivatives by hydrochloric acid process	Noguchi Institute, Shin Nihon Chisso Hiryo
1956	21,000	58,800	Production of polyester filament and its monomer from spent liquid from pulp mill	Kokoku Rayon Pulp Company
1957	14,500	40,600	Spinning test of the above	Do.
1957	6,000	16,800	Development of pre-treatment for wood saccharification	Hokkaido Forestry Development Institute
1958	6,000	16,800	Development of equipment for wood saccharification by dilute acid	Japan Ligno-Chemicals Company

Automatic recording X-ray apparatus.



Pilot plant laboratory interior.

Neutralizer, Lime
Filter—Gypsum
Decolorizing Tank
Filter
Evaporator
Decolorizing Tank
Ion-exchanger
Evaporator
Crystallizer
Centrifuge—Molasses
Dryer
Glucose
Production (per year)
Glucose (crystal) 500t, Molasses 200t
Gypsum 1,800t, Active Carbon 45t

The following points deserve special attention. The concentrated sulphuric acid is added to the wood in a chopper-type mixer at a usage of 0.8 percent, calculated as 100 percent sulphuric acid, on the basis of the oven-dry wood. Temperature at the point of mixing is between 70°–90° C. (158°–194° F.). Residence time in the mixer is only a few seconds. The acidified wood is transferred to the ripening tank by means of a belt conveyor. The ripening tank is a spiral-ribbon mixer in which the acidified wood is cooled while giving the acid opportunity to penetrate fully into the wood fiber. It is claimed that the yield of sugar is 50 percent, based on dry material. At the end of the ripening step, water is added to make the sulphuric acid 20 percent, and in this acid the material is post-hydrolized for 20 minutes at 100° C. (212° F.). The mixture is filtered and the filtrate is neutralized in 2 stages with 20 percent milk of lime. In the first step, the pH is taken to 1.5, and in the second step the pH is taken to 5.5. The gypsum from the first stage can be sold profitably as a coagulation agent in the production of tofu curds. Gypsum produced in the second neutralization step is colored and of poor quality.

Noguchi Institute. This institute is now sponsored by the Asahi Chemicals Company and Shin-Nippon Chisso Company.

In 1947, the Noguchi Institute entered the field of wood chemicals. They started to hydrolize wood by means of a sulphuric acid process but concluded that this process is not economical. As a next step, they explored saccharification by concentrated hydrochloric acid. Their first concern was to develop an acid-resistant metal because at that time no equipment was available in Japan which was resistant to hydrochloric acid. In 1952, they continued to explore the hydrolysis process proper.

In this process the wood is comminuted to particles of the size of sawdust. Hemicellulose is removed by prehydrolysis with dilute hydrochloric acid. The dilute acid is removed by filtration and the wet particles of wood are treated with hydrochloric acid gas which is added in sufficient quantity so that it forms concentrated acid of adequate strength with the water present in the sawdust particles. After hydrolysis, the hydrochloric gas is removed by evaporation. Water is then added and the sawdust is post-hydrolized. The process is claimed to yield approximately 660 pounds of crystallized glucose, 440 pounds of syrup, 220 pounds of xylose, 110 pounds of acetic acid, and 550 pounds of lignin per ton of dried hardwood.

Apparently the greatest difficulty in this process is the packing of the wet sawdust and channeling when hydrochloric acid gas is introduced. Some fundamental research was carried out on this phase with the result that particles of sawdust size can now be hydrolyzed.

Production of crystallized glucose from cellulose on a pilot-plant scale was completed in 1954. Further aid from the government and from the sponsor, New Japan Nitrogenous Fertilizer Company, enabled the institute to construct a large-scale pilot plant in the Minamata Factory with the objective of continuing the development of wood hydrolysis. We understand that the development based on treatment of 1 ton of dry wood (per day?) was successfully completed in 1958. In addition, the Noguchi Institute of Tokyo built a pilot plant in 1957 for the production of furfural from xylose.

Utilization of lignin at Noguchi Institute. Since 1957, research dealing with oxidation, chlorination, or hydrogenation of lignin has been under way. It is claimed that lignin can be liquefied readily by hydrogenation with a cheap catalyst that does not have to be recovered. No details have been published but the following general information is available:

Liquefaction temperature 300–350° C. (572–662° F.).
Pressure of hydrogen gas 250–300 kg/cm² (3,700–4,400 p.s.i.).
One ton of lignin produced 1,650 to 1,720 pounds of oil, equivalent to a yield of 80.7 percent.

COMPOSITION OF LIGNIN OIL

1. Monophenols	
p-cresol	25.0 percent
o-cresol	2.5 percent
4-ethylphenol	5.0 percent
4-propylphenol	3.0 percent
Total	35.5 percent
2. Catechols	12.0 percent
3. Heavy oil (280° C., 540°F. up)	25.0 percent
4. Acetone	8.0 percent

The institute claims to be producing vanillin by oxidation of lignin and also to reform the liquid products from lignin.

Utilization of Pulp Mill Byproducts

Production of Alcohol. According to the Alcohol Monopoly Law, the production of alcohol is the monopoly

Recording infrared spectrophotometer.

Elementary analysis laboratory.

of the government. There are 8 mills which are directly managed by the government and 11 plants of 7 companies which are privately managed. Of these, 3 plants are producing 2,170,000 gallons of alcohol from spent liquor as compared with the total alcohol production in 1956 of 7,430,000 gallons. Historically, Oji Hakko Company Ltd. (Tomakomai, Hokkaido) started the production in November 1948, Kokusaku Pulp Company (Asahigawa, Hokkaido) in 1949, and Sanyo Pulp Company (Iwakuni) in November 1955. The capacity and the production in 1956 for each mill are as follows:

	Capacity	Production Gallons
Oji Hakko Company	380,000	342,000
Kokusaku Pulp Mill Company	660,000	940,000
Sanyo Pulp Mill Company	635,000	860,000

Alcohol is produced in Japan also from molasses and sweet potatoes. The percentage of alcohol produced from spent liquor is increasing. The above mentioned plants use continuous fermentation processes.

Production of Mycotorula Fodder Yeast from Spent Sulphite Liquor. The Inuyama Plant of Toyo Spinning Company is the only plant which produces this fodder yeast. The plant produces dissolving pulp from red pine *(pinus densiflora)* by the sulphite process. They started basic research on fermentation soon after the war, carrying it through the pilot-plant stage in a 5-ton tank. In 1955, they built an industrial plant consisting of a 50-ton tank and 2 sets of fermentation tanks with a total capacity of 7,000 cubic feet. This plant went on stream in September 1955. They recover, per ton of pulp, 0.2 ton of sugar which is converted to about 0.1 ton of yeast, using the aerobic fermentation process developed by Waldhof. Nitrogen and minerals are added as nutrients. The incubation time is 4 to 5 hours after which the yeast is recovered in a centrifuge and dried in a double-drum dryer. The plant treats from 28,000 to 32,000 cubic feet of spent liquor per day, from which they produce 120 to 150 tons of yeast per month which is used for animal food, other food stuffs, and as a source of chemicals. Other applications are under development. The yeast they use is "mycotorula japonica."

Utilization of Tall Oil. The production of crude tall oil in Japan is estimated at around 12,000 tons. Three companies refine the crude tall oil, one of them produces 450 tons monthly by continuous distillation. All of these companies are separating fatty acid, rosin, light oil and pitch.

It is unlikely that the production of tall oil can be increased because the 2 species of pine available, red pine *(pinus densiflora)* and black pine *(pinus thunbergii)* are in short supply.

Production of Furfural. The Yonago Plant of the Nippon Pulp Mill Company produces 5.5 tons of furfural per day as a byproduct. They manufacture 34,000 tons of dissolving pulp per year from hardwood, using the kraft process. They prehydrolyze hardwood by steam, condense the steam, and recover the furfural by fractionation.

Hokkai Paper Company produces furfural in a pilot plant at the rate of 55 pounds per hour, using a continuous countercurrent system. Their raw material is prehydrolysis liquor which they obtain by prehydrolizing certain species of bamboo with dilute sulphuric acid. They claim that the fiber obtained by prehydrolysis is suitable for the production of fiber board. Their data show that for the optimum conditions of the countercurrent process the prehydrolysis liquor should contain about 15 percent sugar, 20 percent of which is hexose. Although the pilot-plant stage of this process has been completed successfully, they are not sure whether the process will perform as well in a production plant

Other Products from Spent Sulphite Liquor. The Iwakuni Plant of the Sanyo Pulp Mill Company is producing 1,000–1,300 tons per month of concentrated liquor containing 55–60 percent solids. This concentrate is produced by means of a quadruple effect evaporator. Capacity of this mill is 2,000 tons per month. Several other mills are producing minor amounts of this concentrate. The concentrate is used as a binder for briquettes and other materials.

Recently, the Kokusaku Pulp Mill Company has started to ferment their spent sulphite liquor. This liquor is then dried and powdered. It is used as a dispersing agent in masterbatched GRS rubber which in turn is used as an additive to Portland cement mixes. The mill produces about 300 tons per month of their dry powder product.

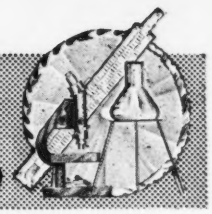
The Kokoku Rayon Pulp Mill Company produces and sells about 2 tons per month of vanillin from spent sulphite liquor.

Turpentine is produced from spent sulphite and sulphate liquors. Some of this turpentine will be used for the production of synthetic camphor.

Although the utilization of sulphite liquor is increasing every year, it is still negligible compared with the total produced in Japan.

Note: All units of measurement have been converted to the American system.

Abstracting the Literature



PAPER AND BOARD

Marton, Renata. (N. Y. State Univ. Col. Forestry, Syracuse). Fiber geometry as related to paper bonding. Tappi 42, no. 12: 948–53 (Dec., 1959).

The study deals with morphol. changes in fiber structure and the geometry of high-yield pulps brought about by delignification, refining, and wet pressing and their effects on paper props. Pulp has been produced from white birch (*Betula papyrifera* Marsh.) by a cold soda technique, in 77.3% yield, then delignified by sodium chlorite from the original 19% to lignin levels of 12 and 2.3%. Handsheets were prepd. from pulps at these three lignin contents under varying degrees of ball milling and wet pressing. The extent of removal of the primary wall and outer layers of the secondary wall was measured in order to assess the potential active fiber surface. The "swellability" of the fibers was detd. for the different refining trmts. Apparent d. and tensile strength have been related to the extent or removal of the primary wall and the outer layer of the secondary wall and to the "swellability" of the fibers at different degrees of beating and wet pressing. From these relations it was observed that the strength devt. was not only a function of primary and secondary wall removal, but depended on other changes in the cell structure which are better reflected in the "swellability" of the fibers. In examg. the cross sections of the corresponding paper specimens, the effects of wet pressing, refining, and lignin removal were seen to change the packing of the fibers in the handsheets, and to deform the fibers. 17 ref. [A.B.I.P.C. 30:8]

TESTING AND ANALYSIS

Meyer-Uhlenried, K. H. A method of preparing wood fibers for measuring purposes. Z. wiss. Mikroskopie 64, no. 5: 303–4 (Nov., 1959). [Ger.; Engl. and Fr. sum.]

Microtome sections (*ca.* 100 μ) of fresh wood samples are macerated gently according to Jeffrey for 12 hr. in a 1 : 1 mixt. of 10% chromic and 10% nitric acid, followed by 2 hr. of gentle shaking and repeated rinsing with water on a fine screen. The macerated matl. is dewatered thoroughly by repeated trmt. with alc. and abs. alc., then pipetted in dil. alc. suspension onto a degreased slide, covered with a thin layer of a special colorless air-drying varnish (Cyclone Lacquer No. 10830), and allowed to dry by evapn. (*ca.* 12 hr.) while protected from dust. This method avoids the frequent crossing, superposition, and injury of macerated fibers being handled with a needle. The special lacquer coating makes cover glasses superfluous and permits the prepn. to be readily removed from the slide and stored (with space savings) between sheets of paper. [A.B.I.P.C. 30:8]

WATER, AIR, GASES, AND VAPORS

Christensen, G. N. The rate of sorption of water vapour by wood and pulp. Appita 13, no. 3: 112–22; discn.: 122–3 (Nov., 1959).

Small samples of klinki pine (*Araucaria klinkii* Lauterb.), less than 2 mm. thick, initially in equil. with WV at a rel. low vapor pressure, were exposed to a higher vapor pressure in the absence of air. The rate at which absorption occurred appeared to be indep. of the thickness of the samples and was much slower than that expected from the rate of water diffusion through wood. For increments over different ranges of vapor pressure, the rate appeared to be a logarithmic function of the pressure ratio. However, when the initial vapor pressure was zero, the rate of sorption was indep. of the final vapor pressure. The equil. moisture content at a given rel. vapor pressure was higher the greater the vapor-pressure increase. A mechanism of sorption based on the relaxation of swelling stresses is proposed. When the wood was progressively delignified without disintegration, the rates of sorption at high vapor pressures were greater than the corresponding rates for the untreated wood. Sorption of WV by sulfate pulp prepd. from klinki pine was considerably faster than by the wood, particularly at high vapor pressures where an increase in rate by a factor of up to 18 was observed. The rates of sorption by papers prepd. from the beaten and unbeaten sulfate pulps were similar. 13 ref. [A.B.I.P.C. 30:8]

WOOD—PROPERTIES AND UTILIZATION

Frey-Wyssling, A. and Bosshard, H. H. Cytology of the ray cells in sapwood and heartwood. Holzforschung 13, no. 5: 129–37 (Nov., 1959). [Engl; Ger. sum.]

As the distance of ray cells from the cambium increases, there is a gradual degradation of the cell nucleus and of the mitochondria; concomitantly, the oxygen supply is impeded. These observations favor the hypothesis that the transition band between sapwood and heartwood is characd. by a "semianaerobiotic metabolism." Starch hydrolysis appears to occur in this zone; after the starch has disappeared, the enzymes in the sapwood seem to lose control over the ray cells. At the boundary of the colored heartwood, an oxidative polymerization of the phenols in this area becomes possible (but only after disappearance of the starch). Since oxygen is no longer used as a hydrogen acceptor in the respiratory cycle, it can oxidize phenols, though very slowly, despite its low tension (*ca.* equal to that of oxygen in com. nitrogen gas). This is in harmony with the known slowness of colored heartwood formation. 23 ref. [A.B.I.P.C. 30:8]

Goldstein, Irving S., Dreher, William A., Jeroski, Edward B., Nielson, J. F., Oberley, William J., and Weaver J. W. (Koppers Co., Inc.) Wood processing; inhibiting against swelling and decay. Ind. Eng. Chem. 51, no. 10: 1313–17 (Oct., 1959).

Swelling and shrinkage of wood with changes in atm. moisture can be substantially reduced by bulking the swollen wood with resins. When pinewood is impregnated with PF resins of various ages which are then further polymerized, the redns. in swelling of trd. wood are related to the methylolphenols content of the aged resin solns. If the hydroxyl groups of the wood cellulose are substituted with ether or ester groups, the wood does not absorb as much moisture and does not swell as much as untrd. wood. β-Propiolactone reacts to form graft polymers on the cellulose chains which reduce the swelling of wood by as much as 70%. Cyanoethylation also substantially reduces the swelling of pinewood. Both kinds of modified wood resist attack by wood-destroying fungi. 16 ref. [A.B.I.P.C. 30:8]

WOOD—SUPPLY AND PREPARATION

Holekamp, J. A. Outside storage of pine chips—Louisiana (Progress Report #2). Tech. Release No. 59-R40. New York, American Pulpwood Assoc., 1959. 4 p.

Pine chips stored outdoors for 3 summer months did not show any signs of wood deterioration. Pulps prepd. from the stored chips showed no significant variation in props. as compared to pulps prepd. from the chips before outside storage. In contrast, pine roundwood stored outside during the same crit. months showed a 3–4% loss in sp. gr., a figure which does not indicate addnl. losses caused by wood-boring insects, fungi, and less favorable pulping qualities. [A.B.I.P.C. 30:8]

Holekamp, J. A. Outside storage of pine chips—Texas (Progress Report #3). Tech. Release No. 59-R41. New York, American Pulpwood Assoc., 1959. 4 p.

The exam. and pulping of pine chips stored for 12–28 weeks in the South indicated that a 4-month storage period produces no more than minor deterioration of the chips. It is noted that a major change in southern wood handling procedures may result from the mounting evidence that little wood deterioration takes place during summer storage of chips. [A.B.I.P.C. 30:8]

LIGNIN AND LIGNIN DERIVATIVES

Wardrop, A. B., and Bland, D. E. The process of lignification in woody plants. Fourth International Congress of Biochemistry. Vol. II. Biochemistry of wood. Australia, Commonwealth Sci. and Ind. Research Organization, 1959. p. 92–116.

A discn. is given of the phys. texture and submicroscopic organization of the cell wall in wood fibers. Evidence indicates that lignin is present mainly between the cellulose microfibrils but may penetrate into them to some degree. Evidence that lignin is concd. mainly in the region of the mid-

dle lamella and primary wall is revd. A description is given of the sequence of changes in the differentiation of wood fibers. Lignification begins in the primary wall at the cell corners and then extends to the middle lamella and secondary walls. The UV absorption spectra of lignin at various levels in the zone of differentiation have been detd. The modification of the lignification process taking place after ring-barking and during formation of reaction wood is described. The sequence of changes in the lignification of primary wood is traced. In all cases the observed complementary distribution of peroxidase and lignin deposition supports the view that at least one peroxidase-controlled phase of lignification proceeds within the cell wall. Theories relating to the origin of lignin precursors are revd. 83 ref. [A.B.I.P.C. 30:9]

MOLDING, HOT PRESSING, AND SHAPING

Plath, Erich. The effect of curing of urea resins on the properties of woodshavings board. Holz Roh- u. Werkstoff 17, no. 12: 490–4 (Dec., 1959). [Ger.: Engl. sum.]

Single-plywood-shavings boards (550 kg./cu. m.) were prepd. using Kaurit 285 urea-resin glue and various proportions of ammonium chloride as curing catalyst (in ammonium hydroxide buffer). Both water-swelling props. and dry strength props. were affected by hot-press time (degree of curing or hardening of the binder). The best board props. were obtained with 15% amonium chloride (based on 65% dry resin wt.); higher amts. gave rough porous surfaces unsuited for pract. use. The presence of ammonia was detrimental for almost all props., tensile strength perpendicular to the surface being the most sensitive. The formulation of the curing mix was esp. important for short pressing times; after prolonged pressing times, some strength props. (but not the swelling behavior) became indep. of the presence or cpn. of the catalyst. Three-ply boards of satisfactory props. were obtained at different curing times: where surface smoothness and d. are important, one might even consider omitting the catalyst entirely. 3 ref. [A.B.I.P.C. 30:9]

WOOD—PROPERTIES AND UTILIZATION

Buro, Andreas, and Buro, Eva-Anne. Studies on the permeability of pinewood. Holz Roh- u. Werkstoff 17, no. 12: 461–74 (Dec., 1959). [Ger.; Engl. sum.]

Theories and definitions of gas and liquid permeability, and porosity are outlined, with particular ref. to wood. The air permeability *(I)* of pinewood *(Pinus silvestris)* was measured with a special app. as a function of several influencing variables. In gen., *I* decreased in sapwood from the outside to the inside, but there was no clearly delineated zone of lower *I* near the heartwood border. *I* increased with increased sapwood thickness, but was not significantly affected by variations in annual ring width. *I* decreased from the lower to the upper part of the trunk. There was no const. relationship between *I* in the three anatomical directions. The ratios of axial or tangential to radial *I* increased with decreasing radial *I*. A gen. higher *I* of spring- or summerwood was not established. Swedish pinewood had a lower radial *I* than German pinewood of comparable sapwood thickness. Solvent extns. increased the *I*; the increase was more marked for samples of initially poor *I*. The possibilities and limitations of *I* measurements on specimens taken with a dowel-cutting drill are discussed. Data on the *I* of wood should be used primarily for characg. and studying wood props., rather than for calcg. the movements of liquids through wood, since many liquids react in various ways with wood and thus change its permeability. 22 ref. [A.B.I.P.C. 30.9]

Echols, Robert M. Variation in tracheid length and wood density in geographic races of Scotch pine. Yale Univ. School Forestry, Bull. no. 64: 1–52 + 5 plates (1958).

A study was made of 17-yr. old Scotch pines from 15 different European seed sources, selected from a plantation established in the Fox Forest, Hillsboro, N. H., in 1936, in an attempt to relate the growth form of each tree to its geographic origin. Correlations with latitude of origin were highly significant for tracheid length, tree height, bark thickness, diam. at breast height, and wood d. Significant relationships were established between the flg.: wood d. and diam. at breast height, width of growth ring and tracheid length, wood d. and tracheid length, tree height and tracheid length, and wood d. and width of growth ring. From the extremely high correlation between tracheid length and tree height, it was suggested that prediction factors could be established for the trees, based on length of tracheids in the juvenile stage. The results of this investigation may serve to guide the growers of Scotch pine in the northeastern U.S. in selecting races for planting to obtain wood with desired d. and tracheid lengths as well as those with economically favorable growth rates. 118 ref. [A.B.I.P.C. 30:9]

Kennedy, R. W., and Jaworsky, J. M. (British Columbia, Univ.) Variation in cellulose content of Douglas-fir. Tappi 43, no. 1: 25–7 (Jan., 1960).

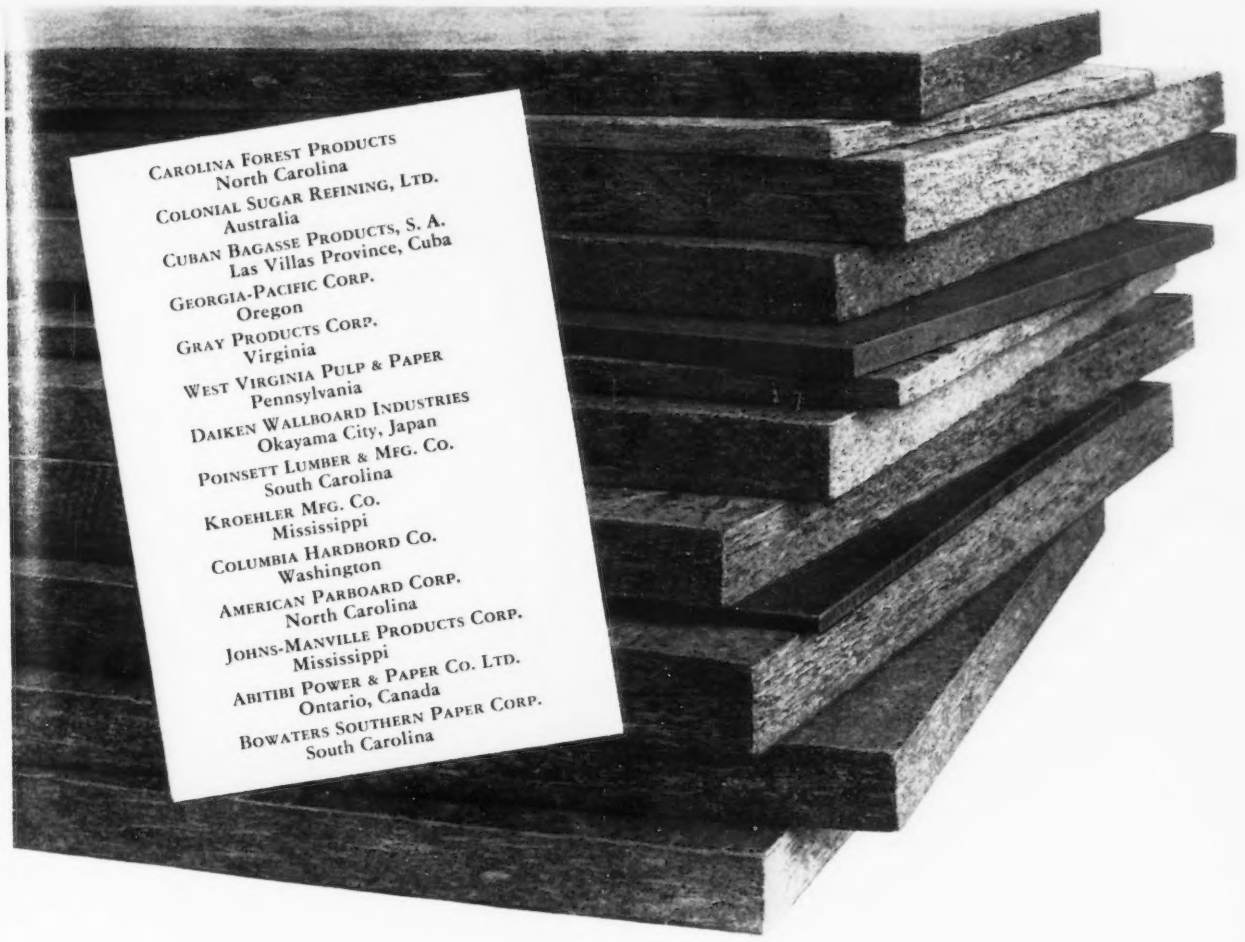
Std. samples from 8 Douglas-fir trees were analyzed for C.&B. cellulose; in addn., a single tree of the group was analyzed from pith to bark. Lower cellulose yields were found in the core than in the outer wood of the single tree. Most of the variation in cellulose content caused by age was found in the first 15 annual rings from the pith. Among the 8 trees sampled, C.&B. cellulose yields varied from 54.9 to 65.4%. Corresponding water-resistant carbohydrate and α-cellulose values ranged from 71.4 to 77.0% and 45.6 to 51.6% resp. Crown class, site, radial position, growth rate, and percentage of summerwood failed to account for the variation observed; the difference between trees was ascribed to variability that is probably genetically controlled. The desirability of propagating trees with high cellulose content is discussed briefly. 6 ref. [A.B.I.P.C. 30:9]

Larson, Philip R. Effect of environment on the percentage of summerwood and specific gravity of slash pine. Yale Univ., School Forestry, Bull. No. 63: 1–80 + 4 plates (1957).

Statist. methods were used to eval. the influence of growth rate, age, geographic location, and environmental factors on the sp. gr. and percentage of summerwood in slash pine. Within the range of ring widths normally encountered in slash pine stands, rate of growth exerted a negligible influence on both sp. gr. and percentage of summerwood; for all pract. purposes its effect may be ignored. The percentage of summerwood was strongly correlated with sp. gr., accounting for 60% of the total variation, whereas the effect of age predominated in controlling the percentage of summerwood gradient on the cross-section. Mean summerwood percentage increased from about 40% at age 6 yr. to about 60% at 21 yr. and tended toward uniformity thereafter. The juvenile wood (up to 6–8 yr.) tended to be inherently low in summerwood. Considerable differences in summerwood percentage and hence in sp. gr. were found between individual trees and between plots. None of the between-tree variation could be accounted for by the factors tested. On a plot basis, summerwood percentage increased from north to south and from west to east within the slash pine range. The only stand variables that could account for any of this between-plot variation were those related to moisture-holding capacity of the soil; high moisture-holding capacity, hence good sites, produced the lowest percentage of summerwood after adjusting for rate of growth. Percentage of summerwood increased with increasing June-July rainfall and decreased with increasing Jan.-Feb. precipitation. The multiple regression of the two variables, June-July rainfall and depth to a fine-textured horizon, accounted for 55% of the total variation in summerwood between plots. 166 ref. [A.B.I.P.C. 30:9]

Truman, A. B. (Anglo Paper Prods. Co.) Variation of moisture content of pulpwood piled in the bush. Pulp Paper Mag. Can. 60, no. 11: 151–2, 154–5, 158–9 (Nov., 1959).

A study was made of the monthly variation in moisture content of spruce and balsam trees and of logs piled in the bush. There is little change in the distribution of moisture in standing trees throughout the summer. For balsam the max variation is 4.5%, and for spruce 6.5%. The difference between the top and bottom of the standing tree is 13% for balsam, but only 5% for spruce. When the moisture content is measured on a gravimetric basis, the mean values for balsam and spruce trees during the summer are 56.5 and 42.8%, resp. The corresponding moisture contents on a volumetric basis are 30.0 and 24.0%. There is no difference in the rate of drying of piled logs when averages by month of cut are compared. When divided into groups by diam., logs having the smallest diam. have the fastest rate of drying. Over the period of 12 months, the balsam logs dropped in moisture content from 55.25% to 41.73% and the spruce logs from 41.5% to 28.25%. The corresponding wt. loss was 25% for balsam and 19% for spruce. [A.B.I.P.C. 30:9]



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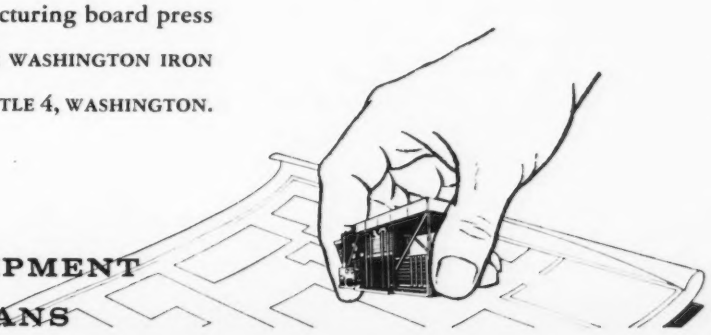

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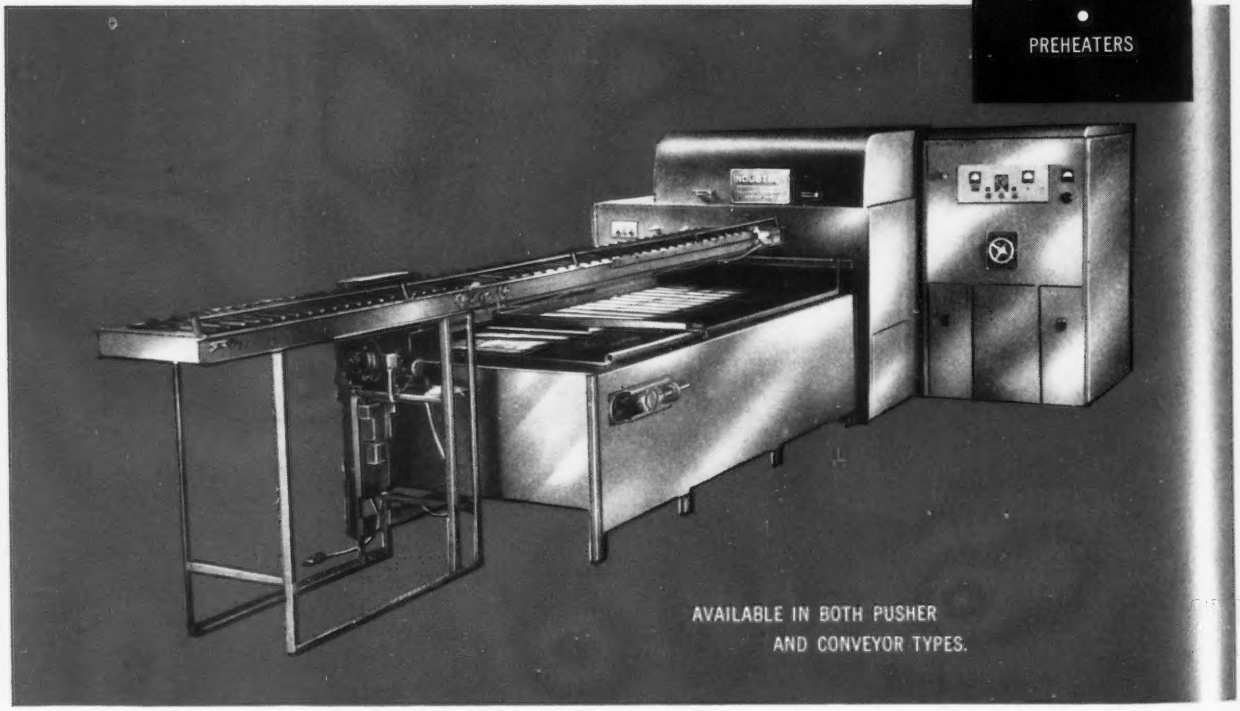

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